



TITLE:

Tax and Social Security Reforms in an Aging Japan(Dissertation_全文)

AUTHOR(S):

Okamoto, Akira

CITATION:

Okamoto, Akira. Tax and Social Security Reforms in an Aging Japan. 京都大学, 2004, 博士(経済学)

ISSUE DATE:

2004-03-23

URL:

<https://doi.org/10.14989/doctor.r11402>

RIGHT:

新制
經
191

学 位 申 請 論 文

岡 本 章

Tax and Social Security Reforms in an Aging Japan

Akira Okamoto

Contents

<i>List of Tables</i>	v
<i>List of figures</i>	vii
<i>Preface</i>	ix
1 Introduction	1
1.1 A life-cycle general equilibrium simulation model	2
1.2 Modeling demographics: comparison of two steady states	3
1.3 Intragenerational equity	4
1.4 Quantitative analysis	4
1.5 Progressive expenditure taxation	5
1.6 Organization of this dissertation	5
2 Taxation of interest income in an aging Japan: simulation analysis using a life-cycle general equilibrium model	9
2.1 Introduction	9
2.2 Theoretical framework	11
2.3 Simulation analysis	16
2.4 Simulation results	20
2.5 Conclusions	28
<i>Appendix 2.A</i>	29
<i>Appendix 2.B</i>	30
3 Progressive taxes and intragenerational redistribution in an aging Japan	38
3.1 Introduction	38
3.2 Theoretical framework	40
3.3 Simulation analysis	47

3.4 Simulation results	50
3.5 Conclusions	55
<i>Appendix 3.A</i>	56
<i>Appendix 3.B</i>	57
<i>Appendix 3.C</i>	58
<i>Appendix 3.D</i>	58
<i>Appendix 3.E</i>	59
4 Simulating progressive expenditure taxation in an aging Japan	69
4.1 Introduction	69
4.2 Theoretical framework	71
4.3 Simulation analysis	73
4.4 Simulation results	76
4.5 Conclusions	82
<i>Appendix 4.A</i>	84
5 Simulating tax reforms with an inheritance tax in an aging Japan	93
5.1 Introduction	93
5.2 Theoretical framework	95
5.3 Simulation analysis	97
5.4 Simulation results	101
5.5 Conclusions	106
<i>Appendix 5.A</i>	107
<i>Appendix 5.B</i>	109
<i>Appendix 5.C</i>	110
6 Integration of tax and social security systems: on the financing methods of a public pension scheme in a pay-as-you-go system	118
6.1 Introduction	118
6.2 Theoretical framework	120
6.3 Simulation analysis	123
6.4 Simulation results	129
6.5 Conclusions	133
<i>Appendix 6.A</i>	136

7	A life-cycle general equilibrium simulation model with continuous income distribution: an application to an aging Japan	144
7.1	Introduction	144
7.2	Theoretical framework	146
7.3	Simulation analysis	152
7.4	Simulation results	155
7.5	Conclusions	158
	<i>Appendix 7.A</i>	158
	<i>Appendix 7.B</i>	159
	<i>Appendix 7.C</i>	161
	<i>Appendix 7.D</i>	162
	<i>Appendix 7.E</i>	164
	<i>Appendix 7.F</i>	165
8	Within-cohort inequality and tax reforms in an aging Japan	171
8.1	Introduction	171
8.2	Theoretical framework	172
8.3	Simulation analysis	175
8.4	Simulation results	178
8.5	Conclusions	181
	<i>Appendix 8.A</i>	182
	<i>Appendix 8.B</i>	183
	<i>Appendix 8.C</i>	185
9	Summary and conclusion	194
9.1	Summary of the whole dissertation	194
9.2	Individual summaries for Chapters 2 through 8	195
9.3	Reservations and suggestions for future research	197
	<i>Notes</i>	201
	<i>References</i>	209

Tables

2.1	Estimation of the age-profile of earnings ability	32
2.2	Parameter values used in simulation analysis	32
2.3	Empirical results caused by different policies of an interest income tax (in the current steady state)	33
2.4	Empirical results caused by different financial methods to cover the increased tax burden in a transition to an aging society, and by different policies of an interest income tax (in an aged steady state)	34
2.5	Sensitivity analysis	35
3.1	Simulation cases	62
3.2	Parameter values used in simulation analysis	63
3.3	Income distribution and taxes of households	63
3.4	Empirical results caused by a progressive labor income tax, a proportional tax, and a progressive consumption tax	64
3.5	Estimation of the age-profile of earnings ability	65
3.6	Sensitivity analysis for exogenous changes in labor supply	65
3.7	Estimation of the age-profiles of earnings ability based on educational backgrounds	65
3.8	Sensitivity analysis for different rates of the adjustment coefficient for discounting the future, δ	66
3.9	Sensitivity analysis for different intertemporal elasticities of substitution, γ	66
4.1	Estimation of the age-profile of earnings ability	87
4.2	Parameter values that characterize the two steady states	87
4.3	Parameter values used in simulation analysis	88
4.4	Income distribution and taxes of households	88
4.5	Empirical results caused by progressive labor income taxation and progressive expenditure taxation	89

5.1	Estimation of the age-profile of earnings ability	112
5.2	Parameter values that characterize the two steady states	112
5.3	Current and aged benchmark cases and empirical results caused by some tax reforms in the 2025 aged steady state	113
5.4	Effects of alternative tax bases on capital accumulation in the 2025 aged steady state under proportional taxation	114
5.5	Parameter values used in simulation analysis	115
5.6	Effective tax rates of wagedworkers on a national income tax and a residence tax (case of a couple with two children)	115
5.7	Changes in the size of four tax bases in a transition from the 2000 current to the 2025 aged steady states	116
6.1	Parameter values employed in simulation analysis	139
6.2	Estimation of the age-profile of earnings ability	139
6.3	Estimation of the parameters of tax progressivity on labor income	140
6.4	Empirical results caused by different tax and public pension systems	141
7.1	Estimation of the age-profile of earnings ability	167
7.2	Parameter values used in simulation analysis	167
7.3	Income distribution and taxes on households	168
7.4	Empirical results caused by different degrees of tax progressivity on labor income and different variances in income distribution	169
7.5	Simulation results for exogenous changes in labor supply	170
8.1	Parameter values that characterize the two steady states	188
8.2	The 2000 current benchmark case A and the 2025 aged state cases, B, C, and D	189
8.3	Empirical results caused by the introduction of a progressive expenditure tax in the 2025 aged steady state	190
8.4	Parameter values used in simulation analysis	191
8.5	Income distribution and taxes on households	192

Figures

1.1	Population pyramids in year 2000 and 2025	8
2.1	Age-profiles of consumption in Cases A-1 (with a 0-percent interest income tax) and A-2 (with a 40-percent interest income tax)	36
2.2	Age-profiles of consumption in Cases A-3 (with a 0-percent interest income tax) and A-4 (with a 40-percent interest income tax)	36
2.3	Age-profiles of consumption in Cases B (with a 20-percent interest income tax) and C (with a 34.7-percent interest income tax)	37
2.4	Age-profiles of consumption in Cases D-1 (with a 0-percent interest income tax) and D-2 (with a 40-percent interest income tax)	37
3.1	Age-profiles of consumption for the high-income class in Cases A-2 (progressive consumption tax) and A-2* (proportional tax)	67
3.2	Age-profiles of assets for the high-income class in Cases A (progressive labor income tax) and A* (proportional tax)	67
3.3	Age-profiles of assets for the high-income class in Cases A-2 (progressive consumption tax) and A-2* (proportional tax)	68
3.4	Age-profiles of earnings ability based on educational backgrounds	68
4.1	Age-profile of savings for the high-income class in Cases B-1 and B-2	90
4.2	Age-profile of assets for the high-income class in Cases B-1 and B-2	90
4.3	Age-profile of disposable labor income for the high-income class in Cases B-1 and B-2	91
4.4	Age-profile of disposable labor income for the high-income class in Cases B-1 and B-1*	91
4.5	Age-profile of consumption for the high-income class in Cases B-1 and B-2	92
4.6	Age-profile of consumption for the high-income class in Cases B-2 and B-2*	92
5.1	Age-profiles of assets for the high-income class in Cases A and B	117

5.2	Changes in the conditional probability that a surviving household dies next year	117
6.1	Distribution of households' annual labor income	142
6.2	Distribution of age-annual labor income	142
6.3	Changes in welfare of 275 income class households	143
6.4	Changes in welfare of 275 income class households	143
7.1	Age-profiles of assets under a progressive labor income tax	170
8.1	Comparison of age-consumption profiles between Cases B and B-1	193

Preface

Japan's population is aging faster than any other in the world, a situation that is causing serious problems for its society. Structural reforms, especially tax and social security reforms, to accommodate this drastic demographic change have become an urgent policy issue. The purpose of this dissertation is to establish guidelines for tax and social security reforms in Japan in terms that are both efficient and equitable. In this study, an extended life-cycle general equilibrium model is employed to rigorously take account of the rapidly aging Japanese population. The simulation approach adopted in our analysis permits us to numerically calculate the effects of alternative policy packages on capital accumulation and economic welfare. This enables us to make proposals for concrete economic policies.

Moreover, we consider here progressive expenditure (or consumption) taxation. Few studies have dealt with this new type of tax regime to evaluate the effects of structural tax reforms. Since there are only a few studies on progressive expenditure taxation, the research here has some merit as a pioneering work. Our simulation results suggest, quantitatively, that a shift to progressive expenditure taxation might overcome the large welfare loss that would occur under the current tax system as Japan ages.

The research underlying this dissertation was conducted between 1996 and 2002. I would like to thank many professors and friends for their helpful comments, suggestions, and discussions during this period. In particular, I would like to express my gratitude to Professor Toshiaki Tachibanaki (Kyoto University) who was my

academic supervisor. In addition to an excellent research environment, he provided me with helpful guidance, valuable comments, and encouraging words. Professors Toshihiro Ihori (The University of Tokyo) and Naosumi Atoda (Keio University) were kind enough to give me many insightful comments and suggestions. I am deeply grateful to my colleagues at Okayama University for giving me the opportunity to undertake a temporary study at Kyoto University, because this dissertation was written during my research there. I also acknowledge the financial support from the Ministry of Education, Culture, Sports, Science and Technology in Japan (the Grant-in-Aid for Scientific Research (C) No.15530215).

Akira Okamoto

The chapters that follow are based on published material:

Chapter 2

Okamoto, A. (1996) "On the Distortion Effect Associated with an Interest Income Tax in Aging Japan (1)/(2): Simulation Analysis by Applying the Life-Cycle General Equilibrium Model," *Kyoto University Economic Review*, Vol. 157, No. 4, 16-29/Vol. 158, No. 2, 58-74 (in Japanese).

Chapter 3

Okamoto, A. (2000) "Heterogeneous Labor Endowments and Tax Reforms in Aging Japan: Progressive Taxes and Intragenerational Redistribution," *Okayama Economic Review*, Vol. 32, No. 1, 1-48 (in Japanese).

Chapter 4

Okamoto, A. "Simulating Progressive Expenditure Taxation in Aging Japan," forthcoming in *Journal of Policy Models*.

Chapter 5

Okamoto, A. (2002) "Simulating Tax-Mix Policies with Inheritance Taxes in Aging Japan," Discussion Paper No. I-45, Department of Economics, Okayama University, March.

Chapter 6

Okamoto, A. and Tachibanaki, T. (2002) "Integration of Tax and Social Security Systems: On the Financing Methods of a Public Pension Scheme in a Pay-as-You-Go System," in T. Ihori and T. Tachibanaki ed., *Social Security Reform in Advanced Countries: Evaluating pension finance*, London and New York: Routledge, 132-160.

Chapter 7

Okamoto, A. (2000) "Income Distribution and Tax Reforms in Aging Japan," *Okayama Economic Review*, Vol. 32, No. 2, 59-98 (in Japanese).

Chapter 8

Okamoto, A. (2002) "Within-cohort Inequality and Tax Reforms in Aging Japan" Presented at the *International Forum on Tax Reforms in Japan*, Economic and Social Research Institute (ESRI), Cabinet Office (Government of Japan), September.

1 Introduction

The Japanese population is aging faster than any other in the world. The percentage of Japan's population aged 65 and above was only 7.1 percent in 1970, but just 30 years later, in 2000, it reached 17.2 percent. A declining birth rate and a rising average life expectancy will continue to push this trend further. This situation is causing serious problems in the Japanese society. Under the current system, an aging population is placing an increasingly heavy burden of inflating pension and medical care expenses on a shrinking working population. For instance, since the current Japanese public pension program is operated in a manner that is almost similar to a pay-as-you-go style, the declining percentage of the working population will have a harmful effect on economic welfare. Hence, structural reforms, especially tax reforms, to accommodate this drastic demographic change, have become an urgent policy issue.

The purpose of this dissertation is to establish guidelines for structural tax reforms in Japan, a society with an aging population. This dissertation evaluates the alternative tax regimes in terms of efficiency and equity to explore an optimum tax scheme. Any persuasive analysis on this subject should include the general equilibrium effects of policy choices on endogenous economic variables such as interest rates, wages, and savings. In particular, the proper choice of tax bases is a significant question, because this choice has important implications for the course of savings and economic growth, the level of economic efficiency, and the distribution of welfare across generations.

1.1 A life-cycle general equilibrium simulation model

In this dissertation, a life-cycle general equilibrium simulation model developed by Auerbach and Kotlikoff (1983a) is used to take account of the rapidly aging Japanese population. This is because the model is suitable as a basic theoretical framework to examine the impact of demographic changes on various social and economic variables. Auerbach and Kotlikoff (1987) is a dissertation written for the purpose of sharing this new perspective on the macroeconomic effects of fiscal policies. They continue to improve the simulation model, and Altig *et al.* (2001) undertook an analysis with the latest, large-scale, dynamic model. Several Japanese researchers have also employed the macro model – Homma *et al.* (1987a) were the first to make an analysis using this model. Iwamoto (1990) incorporated uncertainty regarding the length of individual life and unintended bequests, consistent with its uncertainty, into a life-cycle general equilibrium model.

When we perform an analysis based on a life-cycle model, the crucial problem is whether this model is applicable to Japan, and can it thus substantially explain its society. For example, Horioka *et al.* (2000) suggest two empirical results. One is that bequest motives in Japan are weak on an absolute scale, and also relatively weaker than those in the United States. Majority of bequests in Japan consist of unintended bequests and strategic bequest motives. The former is caused by uncertainty regarding the length of life – our analysis will focus on this bequest motive. The latter means that parents use their wealth (which changes into bequests when they die) as a means of urging their children to look after them.¹

The other is that many of the aged in Japan finance their living expenses by dissaving, and both parents and children are inclined to take selfish actions. These empirical results indicate that the applicability of a life-cycle model to Japan is fairly high, even higher than that in the United States. Hence, the findings of Horioka *et al.* (2000) are likely to support the fact that our analysis based on a life-cycle model, provides a reasonably good description of the actual Japanese situation.

The life-cycle growth model employed in this dissertation is grounded in the microeconomics of intertemporal choice, and the macroeconomics of savings and growth. The simulation model has three features. First, aggregate assets of the economy in each period consist of the assets of different generations that maximize their lifetime utility. This allows us to rigorously analyze changes in the supply of assets caused by demographic changes. Second, assets in the capital market, where aggregate assets appear as real capital, affect the production level. Third, it is possible to estimate realistic consumption-savings profiles for the elderly, by incorporating life-length uncertainty and unintended bequests into the model.

1.2 Modeling demographics: comparison of two steady states

The main contribution of this dissertation is to take account of the effects of the rapid aging of Japan's population on its economy. Figure 1.1 presents the Japanese population pyramids for the year 2000 and 2025, which is obtained from the *Population Projection for Japan 2001-2100*, The National Institute of Population and Social Security Research (2002). The figure suggests that the age composition of Japan's population differs substantially between the current steady state in 2000 and the aged steady state in 2025.

The percentage of Japan's population aged 65 and above will continue to increase, and the trend of an aging population will be further enhanced with a declining birth rate and a rising average life expectancy. In comparison to 2000, the population aged above 65 would increase drastically by 2025. This indicates that the extension of average life expectancy would occur mostly from the above 65 age group. Therefore, we will present the simulation results and their interpretation, while keeping in mind such differences in the population pyramid. In most of the following chapters, the macroeconomic and welfare effects of alternative tax policies will be evaluated in each of the two steady states, one with the current Japanese age structure and the other with the age structure projected for 2025.

1.3 Intragenerational equity

A life-cycle general equilibrium simulation model is suitable as a basic theoretical framework to examine the impact of demographic changes on various economic and social variables. Therefore, there have been many studies that employ this kind of model. For instance, Auerbach and Kotlikoff (1987), Homma *et al.* (1987a), Iwamoto *et al.* (1993), Kato (1998), and Altig *et al.* (2001). However, nearly all of them evaluate only efficiency issues such as the effects of an aging population on production and consumption, and thus on economic growth. These papers ignore the problem of intragenerational equity, namely the redistribution of resources among households that belong to the same cohort. These studies specify the behavior of a single representative individual, making it impossible to deal with intragenerational income redistribution.²

When handling tax reforms, it is vital to investigate not only efficiency but also equity. Differences in the ability of labor supply within each cohort should be incorporated into a life-cycle general equilibrium model. This dissertation incorporates diversity by assuming that each cohort has representative individuals with equal tastes but unequal labor endowments. This enables us to deal with the problem of intragenerational equity as well. Hence, our study should present comprehensive and useful guidelines for tax reforms. Chapters 3 through 5 incorporate three representative households in each cohort, and Chapter 6 incorporates 275 representative households. Moreover, Chapters 7 and 8 incorporate a large number of households approximated by continuous distribution.

1.4 Quantitative analysis

This dissertation adopts a simulation approach to investigate the issues mentioned above. Simulation analysis has the following merits: by a *qualitative* analysis, we can study whether equilibrium exists, and in which direction the changes in economic policies will lead this equilibrium. However, the analysis fails to give numerical rates and quantities in equilibrium. A *quantitative* analysis provides the degree (or

percentage) by which different policies cause a change in the rates and quantities. Therefore, we implement a numerical simulation analysis that can give us a practical tool for tax policies.

The method of simulation employed in our analysis represents the economy as a general equilibrium system. We evaluate alternative economic policies, by comparing the equilibrium solutions that are calculated under given, and other conditions. Hence, this method permits us to numerically calculate various economic variables and to recognize concrete policy implications. It is especially useful when examining policy packages, or when there are plural policies that work in a reverse direction.

1.5 Progressive expenditure taxation

We will take account of progressive expenditure (or consumption) taxation. Few studies have dealt with this new type of tax regime to evaluate the effects of structural tax reforms. Since there are only a few studies on progressive expenditure taxation, our study has some merit as a pioneering work. There are two types of progressive consumption taxes: expenditure tax and sales tax. The former definition is used in this dissertation. Progressive expenditure taxation, a direct tax that is levied on consumers, will be discussed in Chapters 3, 4, 5, 6, and 8.

1.6 Organization of this dissertation

Eight chapters follow this introduction.

Chapter 2 presents a detailed description of the life-cycle general equilibrium simulation model employed throughout this dissertation, and provides a technical discussion of the algorithm used to find the equilibrium of the simulation model. Chapter 2 addresses the problem of choosing among three tax bases, namely, labor income, interest income, and consumption in terms of efficiency. Chapter 2 also investigates the effects of an interest income tax on household behavior and capital formation.

The life-cycle general equilibrium simulation model in Chapter 2 incorporates a single representative household. Thus, Chapter 2 fails to address the problem of intragenerational redistribution. In Chapter 3 we incorporate three representative households with unequal incomes into the simulation model. This enables us to take account of within-cohort inequality. Progressive labor income taxation and progressive expenditure taxation are discussed in Chapter 3, and the method of modeling progressive taxation is explained. Chapter 3 also demonstrates how progressive taxes affect intragenerational redistribution as well as capital formation. Thus, it compares these tax regimes in terms of efficiency and equity.

Chapter 4 investigates the effects of tax reform, from progressive labor income taxation to progressive expenditure taxation. The simulation model used in Chapter 4 is fundamentally the same as that in Chapter 3. Chapter 4 concentrates on the study of progressive expenditure taxation, and examines its effect on capital accumulation and intragenerational income redistribution. Moreover, a concrete method for the implementation of this new type of tax regime is discussed in Chapter 4.

Chapter 5 incorporates an inheritance tax into the simulation model employed in Chapters 3 and 4. An inheritance tax adopted here is assumed to arise from the unintended bequests consistent with uncertainty regarding the length of individual life. The problem of choosing a tax base is discussed once again in Chapter 5. In addition to the three taxes mentioned in Chapter 3, Chapter 5 includes an inheritance tax, and thus examines the effect of the four tax regimes on capital formation. Chapter 5 also seeks an optimum combination of tax schemes, when progressive expenditure taxation is regarded as the nucleus tax.

The purpose of Chapter 6 is to establish guidelines for structural reforms of tax and social security systems in an aging Japan. In the simulation model employed in the earlier chapters, Chapter 6 introduces the basic pension into the public pension system. The empirical aspect is intensified in Chapter 6; most of the parameter values are calibrated based on the data prepared by the Japan Cooperative Association. Chapter 6

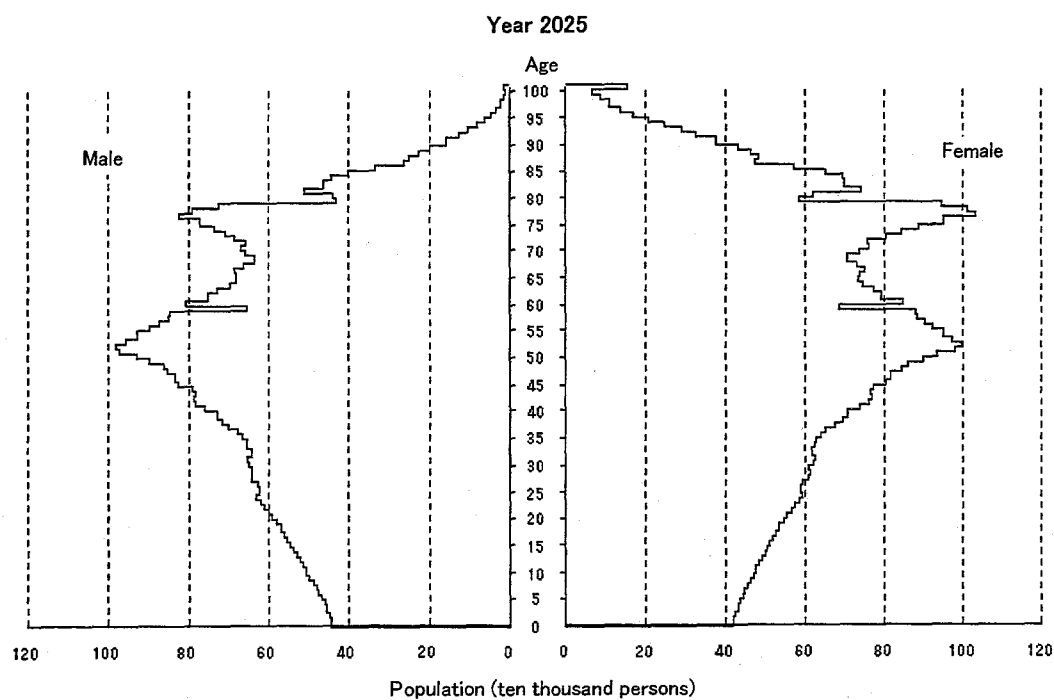
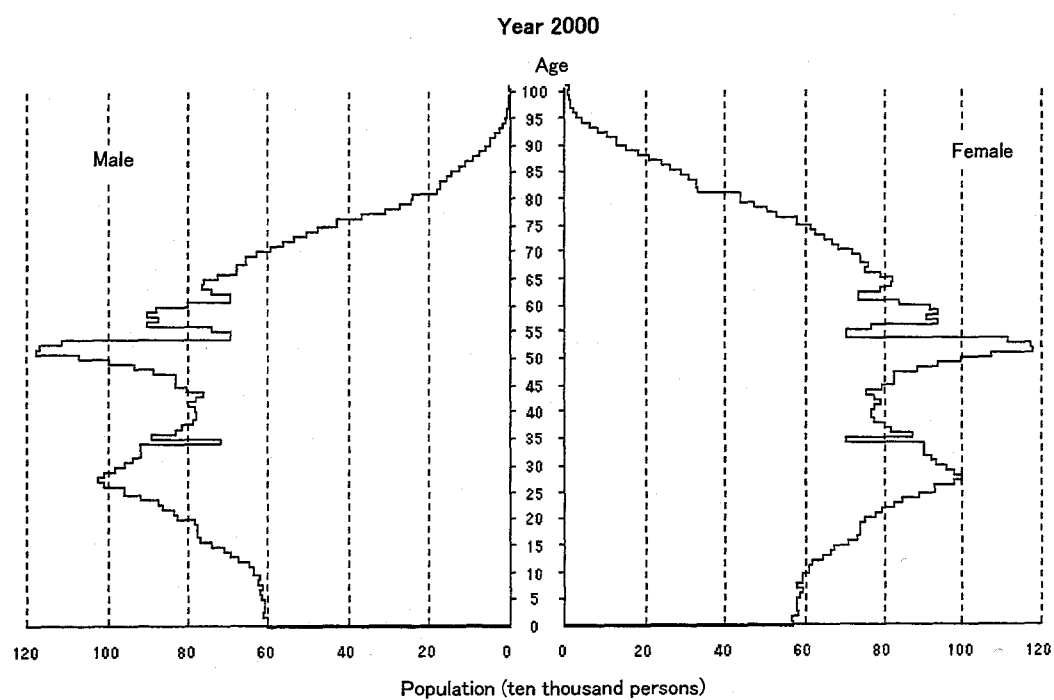
incorporates 275 representative households with unequal incomes, which are estimated using this data.

Chapters 3 through 6 incorporate plural representative households with unequal incomes in each cohort, and address the problem of intragenerational redistribution. However, the changes in the variance of lifetime income distribution are not strictly dealt with. Chapter 7 introduces numerous representative households with *continuous* income distribution into each cohort. This permits us to rigorously analyze changes in variance. When the log of labor income follows a normal distribution, a simulation can easily handle the diverse abilities of labor supply. Thus, Chapter 7 examines the general equilibrium effects of changes in the variance of income distribution, on capital accumulation and social welfare.

Chapter 8 takes account of within-cohort inequality that increases in a transition to an aging society. The simulation model employed in Chapter 8 is basically the same as that in Chapter 7. Chapter 8 demonstrates the general equilibrium effects of an increasing variance in the lifetime income distribution with an aging Japanese population. Chapter 8 also studies the macroeconomic and welfare effects of introducing progressive expenditure taxation in this situation.

Finally, Chapter 9 summarizes and concludes this dissertation. It provides a summary of the whole dissertation, and individual summaries for the findings and conclusions in Chapters 2 through 8. Chapter 9 also presents the reservations in our simulation analysis, and the challenging tasks for future research.

Figure 1.1 *Population pyramids in year 2000 and 2025*



(Source: *Population Projections for Japan 2001-2100*, The National Institute of Population and Social Security Research (2002).)

2 Taxation of interest income in an aging Japan

Simulation analysis using a life-cycle general equilibrium model*

This chapter presents a detailed description of the life-cycle general equilibrium simulation model employed throughout this dissertation, and provides a technical discussion of the algorithm used to find the equilibrium of the simulation model. This chapter addresses the problem of choosing among three tax bases, namely, labor income, interest income, and consumption in terms of efficiency. It also investigates the effects of an interest income tax on household behavior and capital formation.

2.1 Introduction

There has been increasing discussion recently about structural tax reforms in an aging Japan. This chapter will evaluate three alternative tax bases, namely, labor income, interest income, and consumption in terms of efficiency. The chapter will especially focus on the distortion of an interest income tax that affects intertemporal consumption behavior. The impacts of different policies of an interest income tax on savings, capital stock, or economic welfare are analyzed using a life-cycle general equilibrium simulation model. This chapter has two purposes: one is to investigate the distortions of an interest income tax in a quantitative way; the other is to explore an optimum tax

* An earlier version of this chapter was presented at the *1995 Meeting of the Japan Association of Economics and Econometrics (Seibu-bukai)* at Fukuoka University. I am grateful for insightful comments and suggestions by Professors Toshiaki Tachibanaki, Kazuo Yoshida, Masahiro Hidaka, and from the seminar participants. I also acknowledge the financial support from Research Fellowships of the Japan Society for the Promotion of Science for Young Scientists.

system in an aging Japan in terms of efficiency.

This chapter has two themes. One is that it introduces uncertainty regarding the length of life and unintended bequests consistent with its uncertainty, into a simple life-cycle general equilibrium model.¹ To implement a simulation analysis as close as possible to the real world, data on survival probabilities used for life-length uncertainty are obtained from the *Population Projections for Japan 1991-2090*, a 1992 publication by the Institute of Population Problems of the Ministry of Health and Welfare. The other is that most earlier studies define a labor income tax and an interest income tax by the same single parameter as an income tax in the model.² This chapter explicitly separates income tax into two distinct forms: a labor income tax and an interest income tax. This separation allows us to investigate the effects of an interest income tax.

Most earlier papers that study taxation on interest income in Japan have been limited to a partial equilibrium analysis (e.g., Ihori (1994)). To comprehensively analyze the influences of an interest income tax, it is necessary to undertake a general equilibrium analysis. In the framework of a partial equilibrium analysis, for instance, a rise in the tax rate on interest income simply diminishes real income through the income effect. A general equilibrium analysis, however, provides a wider perspective: under revenue neutrality, an increase in the tax revenue from interest income would lower tax rates on other tax bases such as labor income or consumption. The extension to a general equilibrium analysis enables us to examine this comprehensive impact.

The current Japanese income tax system is, in principle, based on consolidated taxation. However, taxation at source and separate taxation are, in reality, widespread in Japan. For example, interest income is separately taxed at 20 percent. In the sense that an interest income tax is completely separated from a labor income tax, our model assumes a separate tax system. Since this chapter isolates the effect of an interest income tax, it is feasible to compare consolidated taxation and separate taxation.

This chapter is organized as follows: Section 2.2 identifies the basic model employed in simulation analysis. Section 2.3 explains the method of simulation analysis and the

assumptions adopted. Section 2.4 evaluates the simulation findings. Section 2.5 summarizes and concludes the chapter.

2.2 Theoretical framework

We calibrate the simulation of the Japanese economy by employing population data estimated by the Institute of Population Problems of the Ministry of Health and Welfare in 1992. The model has 80 different overlapping generations. Three types of agents are considered: households, firms, and the government. Their basic structures are explained in order, and market equilibrium conditions are finally presented.

2.2.1 Household behavior

We assume a single representative household in a cohort, that appears in the economy as a decision-making unit at the age of 21 and lives to a maximum of 100. A household faces an age-dependent probability of death. Let $q_{j+1|j}$ be the conditional probability that a household of age $j + 20$ lives to $j + 21$. Then the probability of a household of age 21 surviving until $s + 20$ can be expressed by

$$p_s = \prod_{j=1}^{s-1} q_{j+1|j}. \quad (2.1)$$

The probability $q_{j+1|j}$ is calculated from data estimated in 1992 by the Institute of Population Problems of the Ministry of Health and Welfare.

The utility of a household depends only on the level of consumption. There is no choice between leisure and labor supply. A household works from age 21 to $RE + 20$, the retirement age. The labor supply is inelastic and after retirement is zero.³ A household that maximizes expected lifetime utility makes lifetime decisions at age 21 concerning the allocation of wealth between consumption and savings. The utility function of a household, whose form is assumed to be time-separable, is

$$U = \frac{1}{1 - \frac{1}{\gamma}} \sum_{s=1}^{80} p_s (1 + \delta)^{-(s-1)} \{C_s\}^{1 - \frac{1}{\gamma}}, \quad (2.2)$$

where C_s represents consumption (or expenditure) at age $s + 20$, δ the adjustment coefficient for discounting the future,⁴ and γ the intertemporal elasticity of substitution between consumption in different years.

The flow budget constraint equation for a household at age $s + 20$ is

$$A_{s+1} = \{1 + r(1 - \tau_r)\}A_s + (1 - \tau_w - \tau_p)we_s + b_s + a_s - (1 + \tau_c)C_s, \quad (2.3)$$

where A_s represents the amount of assets held by a household at the beginning of age $s + 20$,⁵ r the interest rate, w the wage rate per efficiency unit of labor, and e_s the age-profile of earnings ability for a household.⁶ b_s is the amount of public pension benefit, and a_s is the amount of bequest to be inherited at age $s + 20$. τ_w is the tax rate on labor income, τ_c that on consumption, τ_r that on interest income, and τ_p is the contribution rate to public pension program.

The tax system consists of labor income, interest income, and consumption taxes. They all have proportional tax rates. Variables related to the public pension program in a pay-as-you-go system are represented by

$$\begin{cases} b_s = \theta H & (s \geq ST) \\ b_s = 0 & (s < ST) \end{cases}, \quad (2.4)$$

where the age at which each household starts to receive public pension benefits is $ST + 20$, the average annual remuneration is $H \left(= \frac{1}{RE} \sum_{s=1}^{RE} we_s \right)$, and the replacement ratio is θ . Thus b_s reflects the age-profile of labor income.

There are unintended bequests caused by uncertainty regarding the length of life.⁷ The bequests, which were held as assets by deceased households, are handed to surviving 50-year-old households.⁸ Therefore a_s is positive if and only if $s = 30$, and otherwise zero.⁹ When BQ_t is the sum of bequests inherited by 50-year-old households at period t , a_{30} is defined by

$$a_{30} = \frac{BQ_t}{N_t p_{30} (1 + n)^{-29}}, \quad (2.5)$$

where

$$BQ_t = N_t \sum_{s=1}^{80} (p_s - p_{s+1})(1+n)^{-(s-1)} A_{s+1},$$

N_t is the number of new households entering the economy as decision-making units at period t , and n is the common growth rate of successive cohorts.¹⁰ In the steady state of the life-cycle growth model, the amount of inheritance received is linked to the age-profile of assets chosen by individuals.

Let us consider the case in which each household maximizes its lifetime utility under a constraint. Each household maximizes equation (2.2) subject to equation (2.3) (see Appendix 2.A). From the utility maximization problem, the equation expressing evolution of consumption over time for each household is characterized by

$$C_{s+1} = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \right]^{\gamma} C_s. \quad (2.6)$$

If initial consumption level, C_1 , is specified, optimal consumption behavior of all ages can be derived from equation (2.6). The amount of assets held by a household at each age can be obtained from equation (2.3). The expected lifetime utility of a household is derived from equation (2.2).¹¹

When comparing steady states, it is not necessary to take account of the utilities of all overlapping generations existing at period t . A comparison of the lifetime utility of a single cohort is sufficient, because our purpose is to compare the welfare level among simulation cases with alternative tax regimes.

2.2.2 Firm behavior

The model has a single production sector that is assumed to behave competitively using capital and labor, subject to a constant returns-to-scale production function. Capital is homogeneous and non-depreciating, while labor differs only in its efficiency. All forms of labor are perfect substitutes. Households of different ages, however, supply different amounts of some standard measure per unit of labor input.

The production function is assumed to be of the constant elasticity of substitution form:

$$Y_t = B \left[\varepsilon K_t^{1-\frac{1}{\sigma}} + (1-\varepsilon) L_t^{1-\frac{1}{\sigma}} \right]^{\frac{1}{1-\frac{1}{\sigma}}}, \quad (2.7)$$

where Y_t represents the total output, K_t the total capital, L_t the total labor supply measured by the efficiency units, B a scaling constant, ε a parameter measuring the intensity of use of capital in production, and σ the elasticity of substitution between K_t and L_t . Using the property subject to a constant returns-to-scale production function, we can obtain the following equation:

$$Y_t = rK_t + wL_t. \quad (2.8)$$

2.2.3 Government behavior

The government sector consists of a narrower government sector and a pension sector. The narrower government sector collects taxes and spends them on general governmental expenditure. There is no outstanding debt, and thus balanced budget policies are assumed. The budget constraint of narrower government sector at time t is given by

$$G_t = T_t, \quad (2.9)$$

where G_t is government spending on goods and services in year t , and T_t is the total tax revenue from labor income, interest income, and consumption. The public pension system is assumed to be a simple pay-as-you-go schedule. The budget constraint of pension sector at time t is given by

$$R_t = B_t, \quad (2.10)$$

where R_t is the total contributions to pension program, and B_t is the total pension benefits to generations of age $ST + 20$ and above.

Both of these sectors are financed independently and separately. In other words, no transfer is made between the sectors.¹² G_t , T_t , R_t , and B_t are defined respectively by

$$G_t = N_t \sum_{s=1}^{80} p_s (1+n)^{-(s-1)} g, \quad (2.11)$$

$$T_t = \tau_w w L_t + \tau_r r A S_t + \tau_c A C_t, \quad (2.12)$$

$$R_t = \tau_p w L_t, \quad (2.13)$$

$$B_t = N_t \sum_{s=57}^{80} p_s (1+n)^{-(s-1)} b_s, \quad (2.14)$$

where g is annual government expenditure for each cohort. Aggregate assets supplied by households, $A S_t$, and aggregate consumption, $A C_t$, are obtained by

$$A S_t = N_t \sum_{s=1}^{80} p_s (1+n)^{-(s-1)} A_s, \quad (2.15)$$

$$A C_t = N_t \sum_{s=1}^{80} p_s (1+n)^{-(s-1)} C_s. \quad (2.16)$$

2.2.4 Market equilibrium

Finally, equilibrium conditions for the capital, labor, and goods markets are described.

1 Equilibrium condition for the capital market

Since aggregate assets supplied by households are equal to real capital, we get

$$A S_t = K_t. \quad (2.17)$$

2 Equilibrium condition for the labor market

Measured in efficiency units, since aggregate labor demand by firms is equal to aggregate labor supply by households, we obtain

$$L_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s. \quad (2.18)$$

3 Equilibrium condition for the goods market

As aggregate production is equal to the sum of consumption, investment, and government expenditures, we get

$$Y_t = A C_t + (K_{t+1} - K_t) + G_t. \quad (2.19)$$

An iterative program is performed to determine the equilibrium values of the above equations.

2.3 Simulation analysis

2.3.1 Method of simulation

In modeling demographics, the effects of demographic changes are taken into account by comparing two steady states; current and aged. The welfare and macroeconomic effects of alternative tax policies will be evaluated in each of two steady states, one with the current Japanese age structure and the other with the age structure projected for 2025. This chapter considers the steady state as it was in 1990, the current state, and the steady state as it will be in 2025, the aged state. Different survival probabilities (p_s) and different growth rates of successive cohorts (n) create different age structures of the population between the two demographic regimes.

Tax revenue neutrality is assumed to ascertain the clear effects of structural tax reforms. Our study holds that tax revenue is constant across all cases in the method that follows. The number of new households entering the economy, N_t , is adjusted to keep the same size of population between the current and aged steady states. The government expenditure per representative household, g , is exogenously given and constant. Thus, the total tax revenue, T_t , is exogenous and the same across all simulation cases.

As for the tax system, the tax rates on labor income (τ_w) and consumption (τ_c) are exogenously given. Under tax revenue neutrality, the tax rate on interest income (τ_r) is made endogenous. As for the public pension system, the replacement ratio (θ) is exogenously given, and hence, the contribution rate (τ_p) is made endogenous under the pay-as-you-go scheme.

2.3.2 Solution method and computation process

The simulation model presented in the previous section is solved under a hypothesis of perfect foresight by households. Households correctly anticipate the interest, wage, and tax rates. If tax and public pension systems are determined, the model can be solved using the Gauss-Seidel method. The outline of a computation process is as follows.

Step 1

The interest rate r^0 , the wage rate w^0 , the bequest amount for a representative household a^0 , the tax rate on consumption τ_c^0 , and the contribution rate to a public pension scheme τ_p^0 are chosen as initial values.

Step 2

A household that maximizes the lifetime utility determines the time paths of consumption C^1 and savings S^1 for an entire life cycle, by taking the previous values and the tax rates on labor income τ_w and interest income τ_r as given.

Step 3

Aggregate capital K^1 is obtained by summing the assets of all overlapping generations existing at a given period. Then, the production equilibrium conditions, which are led by equation (2.7), bring about a new interest rate r^1 and a new wage rate w^1 . The sum of bequests BQ^1 is derived from the time path of assets A^1 , which generates a new amount of bequest a^1 .

To balance the account of a narrower government sector, the tax rate on consumption changes to τ_c^1 . Similarly, to balance the account of a public pension sector, the contribution rate changes to τ_p^1 .

Step 4

Using r^1 , w^1 , a^1 , τ_c^1 , and τ_p^1 as new initial values, we return to Step 1. This method is iterated until stable variables (or equilibrium) are obtained.

2.3.3 Simulation cases

Let us explain simulation cases. First, we investigate the impacts of different policies of an interest income tax in the 1990 current steady state (the benchmark case A). Next, we examine the effects of different financial methods to cover an increased tax burden, caused by the transition from the current state (Case A) to the aged state (Cases B, C,

and D).¹³ In Case B a labor income tax covers the extra tax burden, in Case C an interest income tax, and in Case D a consumption tax. Finally, in Case D, where the highest economic welfare is attained in the aged steady state, we evaluate the influences of different tax policies on interest income and consider ten simulation cases:

1 Case A

The 1990 current steady state has the following property; the tax rate on labor income is set to 7 percent.¹⁴ Tax rates on interest income and consumption are set to 20 and 5 percent, respectively, which are the current Japanese rates.

2 Case A-1

In Case A, the tax rate on interest income is lowered to 0 percent. A labor income tax covers the loss of tax revenue. The tax rate on consumption remains unchanged.

3 Case A-2

In Case A, the tax rate on interest income is raised to 40 percent. The tax rate on labor income is lowered under revenue neutrality. The tax rate on consumption remains unchanged.

4 Case A-3

In Case A, the tax rate on interest income is lowered to 0 percent. A consumption tax covers the loss of tax revenue. The tax rate on labor income remains unchanged.

5 Case A-4

In Case A, the tax rate on interest income is raised to 40 percent. The tax rate on consumption is lowered under revenue neutrality. The tax rate on labor income remains unchanged.

6 Case B

In the aged steady state of 2025, a labor income tax covers the tax burden that increases in a transition to an aging society. Tax rates on interest income and consumption remain the same as in Case A.

7 Case C

In the aged steady state of 2025, an interest income tax covers the tax burden that increases with an aging society. Tax rates on labor income and consumption remain the same as in Case A.

8 Case D

In the aged steady state of 2025, a consumption tax covers the tax burden that increases with an aging society. Tax rates on labor income and interest income remain the same as in Case A.

9 Case D-1

In Case D, the tax rate on interest income is lowered to 0 percent. A consumption tax covers the loss of tax revenue. The tax rate on labor income remains unchanged.

10 Case D-2

In Case D, the tax rate on interest income is raised to 40 percent. The tax rate on labor income is lowered under revenue neutrality. The tax rate on consumption remains unchanged.

When the tax rate on interest income is lowered (Cases A-1, A-3, and D-1), it is set to 0 percent. This setting takes into account the discussion of an abolition of an interest income tax. When the tax rate on interest income is raised (Cases A-2, A-4, and D-2), it is set to 40 percent for reasons of symmetry. If the tax rate on interest income is changed, Cases A-1, A-2, and D-2 adjust the tax rate on labor income to maintain revenue neutrality, and Cases A-3, A-4, and D-1 the tax rate on consumption.

2.3.4 Parameterization of the simulation model

This chapter examines the implications of several tax policies for an aging Japanese economy. We choose realistic parameter values, which are assigned making reference to earlier research, for example, Homma *et al.* (1987b) in which the values are estimated using Japanese data (see Table 2.2 for the parameter values employed in simulation

analysis). Thus, economic variables, such as the ratios of capital to income (K/Y) and capital to labor (K/L), are close to actual values of 1990. In Case A (benchmark), the interest rate is adjusted to 4.0 percent and the wage rate to approximately unity (0.989).

Next, we describe the setting of parameter values on the modeling of demographics. Survival probabilities (p_s) are calculated from the *Population Projections for Japan 1991-2090*. Our model makes no sex distinction, and so this study uses the male-female average values for 1990 and 2025. The common growth rates of successive cohorts (n) are set to 0.01 in the current and to zero in the aged states. Based on the above data, the ratio of aged population (65 or above) to the total population (21 or above) in 2025 is 0.328: it is 0.299 in our simulation. This indicates that the population structure in our simulation is fairly realistic.

The assignment of parameter values on a public pension program is explained.¹⁵ Atoda and Kato (1993) set the replacement ratio of pension payments at 65 percent of an average annual remuneration. Kato (1998) sets the ratio at 68 percent. In our simulation, the ratio is set to 65 percent.¹⁶ The replacement ratio is an exogenous variable, and thus the contribution rate is endogenous.

2.4 Simulation results

Before presenting the simulation results and the interpretation, we briefly survey earlier studies on the economic effects of an interest income tax and finally show the policy implications obtained by the simulation analysis.

First, a partial equilibrium analysis using a two-period model presents the following view. If an interest income tax is introduced, we cannot theoretically determine whether it decreases or increases savings: since substitution and income effects work in opposite directions, its effect on savings is unclear. The substitution effect weakens the relative attraction of savings, and thus diminishes savings. On the other hand, the income effect increases savings, because a decrease in the real income reduces current consumption. Which effect is larger cannot be determined a priori.

Next, according to the earlier studies that compared labor income and interest income taxes, we cannot theoretically determine which tax system between the two tax regimes is superior in terms of efficiency. Atkinson and Stiglitz (1976), however, suggest that under a specific assumption of individual preferences, i.e., the separability of goods and leisure, the absence of any taxation of interest income is theoretically preferable.

Finally, an interest income tax has two properties. One is that since it reduces the after-tax discount rate, it increases the present value of lifetime income. A decrease in the discount rate enhances the present value of future labor income, and thus stimulates current consumption. This effect is called the "human capital effect," first pointed out by Summers (1981). That study suggests that this intertemporal effect is fairly large. The other is that an interest income tax changes the relative price of intertemporal consumption. An interest income tax levies on interest arising from savings, which differ from common goods because assets are accumulated for future consumption. Hence, an interest income tax distorts the relative price between current consumption and future consumption. Since an interest income tax raises the relative price of future consumption, households that maximize their lifetime utility are likely to substitute current consumption for future consumption.

2.4.1 Simulation results and their interpretation

1 The impacts of different policies of an interest income tax in the 1990 current steady state

The transition from Case A-1 to A-2 (tax rate on interest income: from 0 percent to 40 percent) enables us to investigate the effects of an interest income tax, when a labor income tax is used for revenue adjustment (see Table 2.3). The capital-labor ratio (K/L) is reduced from 3.03 to 2.86. This result suggests that an interest income tax in a relative sense causes damage to capital formation. Figure 2.1 presents the age profiles of consumption in Cases A-1 and A-2. The slope of the profile in Case A-2 with a 40-percent interest income tax is gentler and lower, which reflects the substitution from

future to current consumption. The discount rate in equation (2.6) determines the slope of the curve. The rate decreases from 1.039 to 1.026, which means a lower slope.

The move from Case A-3 to A-4 (tax rate on interest income: from 0 percent to 40 percent) enables us to examine the effects of an interest income tax, when a consumption tax is employed for revenue adjustment. The capital-labor ratio (K/L) diminishes substantially from 3.21 to 2.69. Although the qualitative influence on capital accumulation is the same as in the case where a labor income tax is used for the adjustment, the quantitative effect is much larger. An increase in the proportion of a consumption tax stimulates capital accumulation. This stimulation would increase aggregate production, resulting in a higher level of economic welfare.

The great difference in the timing of taxation between a consumption tax and a labor income tax, may explain why a consumption tax substantially promotes capital formation. Taxation on consumption arises throughout an individual's entire lifetime. On the other hand, the taxation on labor income is limited to the earlier stage, namely, the working period of an individual's lifetime. The tax burden on labor income is concentrated in the working period, while that on consumption exists continuously, even after retirement. A consumption tax requires more assets to cover the tax burden after retirement. Even if the tax revenue is the same at a macro level, a labor income tax imposes a heavier present value on the lifetime tax burden. Since a labor income tax could bring a greater distortion on household behavior, the level of an individual's utility is lower under a labor income tax than under a consumption tax. In Case A-3, the absence of an interest income tax relatively enhances capital accumulation. Moreover, since a consumption tax is employed for the maintenance of revenue neutrality, the tax rate on consumption is the highest among all the simulation cases. Therefore, Case A-3 attains the highest levels of capital formation and economic welfare among all cases.

The influence of an interest income tax on the age-profile of consumption is qualitatively the same as in the transition case from Case A-1 to A-2 (the revenue adjustment made by a labor income tax). Figure 2.2 suggests that during the transition

from Case A-3 to A-4, the slope of the profile is lowered. The discount rate that determines the slope decreases from 1.036 to 1.028. This decrease is smaller than that in the case above, where the adjustment is made by a labor income tax. This may be caused by differences in the time path of taxation during an individual life cycle between a labor income tax and a consumption tax.

An interest income tax promotes the substitution from future to current consumption, and thus it mitigates the slope of the age-profile of consumption. Our simulation results suggest, quantitatively, that an interest income tax substantially hinders capital accumulation. These results may depend on both the substitution effect and the total change of the discounted present value of lifetime income. In the framework of a partial equilibrium analysis, an interest income tax simply reduces the real income by an “income effect.” However, if we adopt the discounted present value of lifetime income as a notion of income, then the “real income” may increase. It should be noted that the direction of changes between the discounted present value of lifetime income and the “income effect” is opposite. For example, in the transfer from Case A-1 to A-2, the tax rate on interest income rises from 0 percent to 40 percent (the revenue adjustment is made by a labor income tax). In this case, the discounted present value of lifetime income increases substantially from 42.0 to 60.0. This result shows that the “human capital effect” first pointed out by Summers (1981) is substantial.

There are two possible explanations for this simulation result. One is that under revenue neutrality, a decrease in the tax rate on labor income (from 9.4 percent to 4.6 percent) influences the real income defined by the discounted present value of lifetime income. In the framework of a partial equilibrium analysis, when the tax rate on interest income is raised, an “income effect” reduces the return from savings, resulting in a decrease in the real income. However, in the framework of a general equilibrium analysis, as in our analysis, additional factors such as a reduction in the tax rate on labor income increase the discounted present value of lifetime income. The other is the influence on the discount rate of the “human capital effect”. When the tax rate on

interest income is raised, the discount rate decreases. For instance, in the transition from Case A-1 to A-2, the discount rate falls from 1.039 to 1.026. The change in the interest rate, r , is limited only from 0.039 to 0.042. Therefore, a decrease in the discount rate depends on a rise in the tax rate on interest income (from 0 to 0.4).

2 The impacts of different financial methods to cover the tax burden that increases in a transition to an aging society, and of different policies on an interest income tax in an aged steady state

We first compare the cases in which a labor income tax, an interest income tax, or a consumption tax cover the tax burden that increases in a transition to an aging society (see Table 2.4). Case D, where a consumption tax covers the increased tax burden, attains the highest amount of capital stock (capital-labor ratio (K/L) of 2.78) and the highest level of utility of -7.510 . It should be noted that although Case B (where a labor income tax covers the increased burden) obtains a higher amount of capital stock than Case C (where an interest income tax covers the increased burden), the utility level in Case B is lower: the capital-labor ratio (K/L) is respectively 2.63 and 2.54, while the utility level is respectively -7.892 and -7.750 . These results may be explained by the difference in the age-profiles of consumption between Cases B and C (see Figure 2.3).

A comparison of Cases B and C is one between cases with different tax rates on interest income when a labor income tax is employed for revenue adjustment; we can consider this comparison in the same manner as that of Cases A-1 and A-2. Compared with Case C, Case B has a lower tax rate on interest income (20 percent against 34.7 percent), and the slope of the age-profile of consumption is steeper: the discount rate is 1.039, while it is 1.033 in Case C. The utility level in Case B is lower in spite of a larger capital stock. This may be related to the discount factor between current and future consumption in the utility function. The taxation on interest income distorts households' consumption-savings behavior by substituting current for future consumption. Since the utility function in our model gives a higher weight to current consumption, the utility in Case C is enhanced by this discount factor. Promoting savings would stimulate

capital formation, increase aggregate production, and thus improve economic welfare at a macro level. At the same time, households restrain current consumption to increase that in the future. This diminishes the utility level through the discount factor in the utility function.

Therefore, taxation on interest income has two effects on individual utility. First, the taxation has a *negative* impact: compared with the other taxes, it relatively hinders capital accumulation, lowers aggregate production, and thus reduces aggregate consumption. Second, the taxation promotes current consumption by substituting it for future consumption, which has a *positive* impact through the discount factor of the utility function: this effect depends on the values of the discount parameters employed, such as subjective discount rates and expected survival probabilities. The relative size of these two opposite effects determines the influence of an interest income tax on the utility level.

A comparison of Cases C and D is one between cases with different tax rates on interest income, when a consumption tax is used for revenue adjustment. In other words, we can consider this comparison in the same manner as that of Cases A-3 and A-4. The influence of an interest income tax on capital accumulation and on the age-profile of consumption in the aged steady state is qualitatively the same as that in the current steady state.

In Case D where a consumption tax covers the increased tax burden in a transition to an aging society, we investigate the effects of different tax policies on interest income. Case D attains the highest level of utility (i.e., -7.510) among the three financial methods. To explore an optimal tax regime, we set Cases D-1 and D-2 by taking account of the simulation results so far. In Case D-1, when the tax rate on interest income is lowered from 20 percent to 0 percent, a consumption tax covers the revenue loss (tax rate on consumption: 6.9 percent to 9.3 percent). In Case D-2, when the tax rate on interest income rises from 20 percent to 40 percent, the tax rate on labor income is lowered from 7 percent to 4.4 percent under revenue neutrality. The simulation results

perform better in Cases D-1 and D-2 than in Case D: the utility improves to -7.317 and -7.406 , respectively. These cases differ in the shape of their age-profiles of consumption, and their levels of capital stock. Figure 2.4 suggests that Case D-2 has a gentler profile slope resulting in substantially less capital stock.

Since the simulation results are dependent on the given parameters, we must be careful about the effects of any parameter changes.¹⁷ In particular, a slight change in the parameter of intertemporal elasticity of substitution, γ , substantially affects capital formation (see Appendix 2.B for the sensitivity analysis).

2.4.2 Policy implications

The policy implications suggested by the simulation results are discussed. In both the current and aged steady states, a rise in the proportion of a consumption tax enhances the capital-labor ratio (K/L) and economic welfare. Here, we should note the following precondition: only in a situation where an economy has a lack of capital stock, is the promotion of capital formation desirable. The capital-labor ratio (K/L) in the simulation is lower in the aged steady state than in the current steady state: in the current benchmark case A the ratio is 2.98; in the aged period it decreases to 2.78 even in Case D, which has the best method for capital accumulation, namely, a consumption tax that covers the tax burden that increases in a transition to an aging society. Thus, it is anticipated that capital accumulation would decline in an aging Japan.

In terms of efficiency, a consumption tax is the best tax regime. However, a consumption tax is likely to be regressive (although this chapter does not treat this aspect). When there are difficulties such as political reasons in raising the tax rate on consumption, it is necessary to consider an optimum combination between a labor income tax and an interest income tax. The simulation results suggest that choosing only one tax regime from these two taxes is not the best: when the tax rate on consumption is 5 percent, an optimum tax rate on interest income is 20 percent in the current state and 40 percent in the aged state.

By comparing Cases A, A-1, and A-2 in the current state, we can investigate an optimal combination between labor income and interest income taxes under a 5-percent consumption tax condition. The simulation indicates that when the tax rate on interest income is 20 percent (in Case A), the utility is the highest (-3.813). When the rate is 40 percent (in Case A-2), the utility is -3.842. When interest income is not taxed (in Case A-1), the utility is the lowest (-3.868). Thus, in the current-state simulations, the current Japanese tax rate of 20 percent on interest income is supported under a 5-percent consumption tax condition.

As for the aged-state simulations, Table 2.4 presents only the cases where tax rates on interest income are 20 percent (Case B) and 34.7 percent (Case C), although many other combinations were implemented. When the tax rate on interest income is 40 percent (and the tax rate on labor income is 5.2 percent), the utility is the highest (-7.733). Hence, if it is difficult to raise the tax rate on consumption, the best combination in an aged-state may be to lower the tax rate on labor income, and to raise the tax rate on interest income to more than the current rate of 20 percent.

A decrease in the proportion of the working population in a transition to an aging society will increase tax and social security burdens. The simulation results suggest that the contribution rate to a public pension program increases drastically from 19.1 percent to 30.3 percent. This diminishes substantially the households' disposable labor income. Therefore, in an aging society, the tax rate on labor income should be relatively lower, considering the balance of this tax burden in relation to other tax regimes.

Finally, in terms of efficiency consolidated and separate taxes are evaluated. Our simulation result did not support consolidated taxation, which levies a tax on labor income and interest income at the same tax rate. This is because this tax regime cannot take account of the property of an interest income tax, which distorts household behavior through a change in the relative price for intertemporal consumption. Moreover, an optimal combination of taxes on labor income and interest income differs between the current and aged states. Therefore, the tax rate on interest income should

be determined separately and carefully, taking account of several factors such as the economic specificity of the taxation of interest income, or the balance of this tax burden in relation to other tax regimes. Hence, our simulation suggests that in terms of efficiency, separate taxation is preferable to consolidation.

According to Ihori (1994), consolidated taxation is based on weak grounds in terms of efficiency, because economic backgrounds differ between labor income and the revenue from savings. Thus, that study reaches the same conclusion as our analysis. It should be noted that this remark concerns only the aspect of efficiency: this chapter cannot deal with the problem of intragenerational equity, because it assumes many identical households in each cohort, expressed by a single representative household.¹⁸

2.5 Conclusions

This chapter has evaluated three tax bases, namely, labor income, interest income, and consumption in terms of their efficiency. We have investigated the effects of the three tax regimes on savings, capital stock, and economic welfare in Japan, where the population is undergoing an aging trend. We have especially focused on the study of an interest income tax. To analyze the above problem, we employed a simulation approach to the extended life-cycle general equilibrium model of overlapping generations, with the introduction of life-length uncertainty and unintended bequests. The following three conclusions have been drawn.

The first concerns the influence of an interest income tax on the Japanese economy. Our simulation results indicate, quantitatively, that taxation on interest income promotes a substitution from future to current consumption, and thus the slope of the age-profile of consumption becomes gentler. Therefore, compared with other taxes, this taxation relatively hinders capital accumulation. We also examined the general equilibrium effect of an interest income tax. In the framework of a general equilibrium analysis, a rise in the tax rate on interest income has a substantial negative effect on capital accumulation, not only from the substitution effect but also by the total change

in real income. The negative impact of an interest income tax on savings is much larger in a general equilibrium model than in a partial one.

The second concerns choosing, in terms of efficiency, an optimal tax system for an aging Japanese population. A rise in the proportion of a consumption tax to the whole taxation stimulates capital formation, which improves the households' utility. A consumption tax is the most advantageous tax regime in terms of efficiency. In a situation where it is difficult to raise the tax rate on consumption, we should consider a combination of taxes on labor income and interest income: optimum combinations differ between the current and aged steady states. In the current state, the tax rate on interest income should be 20 percent, namely, the current Japanese rate. In the aged state, a lower tax rate on labor income and a higher tax rate on interest income are desirable. This is because under the current Japanese system, an aging population is placing an increasingly heavy burden of inflating pension expenses on a shrinking working population.

The third concerns a comparison of consolidated and separate taxations. The tax rate on interest income should be chosen separately and carefully, considering the distortions of the taxation through a change in the relative price of intertemporal consumption. Therefore, we recommend separate rather than consolidated taxation.

Appendix 2.A

We consider the utility maximization problem over time for a representative household, namely the maximization of equation (2.2) subject to the flow budget constraint equation (2.3). Let the Lagrange function be

$$L = U + \sum_{s=1}^{80} \lambda_s \left[-A_{s+1} + \{1+r(1-\tau_r)\}A_s + (1-\tau_w-\tau_p)we_s + b_s + a_s - (1+\tau_c)C_s \right],$$

where λ_s represents the Lagrange multiplier for equation (2.3).

The first-order conditions for $s = 1, 2, \dots, 80$ can be expressed by

$$\frac{\partial L}{\partial C_s} = p_s(1+\delta)^{-(s-1)}\{C_s\}^{-\frac{1}{\gamma}} - \lambda_s(1+\tau_c) = 0, \quad (2.A)$$

$$\frac{\partial L}{\partial A_{s+1}} = -\lambda_s + \lambda_{s+1}\{1 + r(1 - \tau_r)\} = 0. \quad (2.B)$$

The combination of equations (2.A) and (2.B) yields the equation that determines the slope of the age-consumption profile over the life cycle:

$$C_{s+1} = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1 + r(1 - \tau_r)}{1 + \delta} \right\} \right]^\gamma C_s. \quad (2.6)$$

For a given C_1 , equation (2.6) solves the age-path of consumption. The transformation of equation (2.6) leads to the following expression:

$$C_s = \left(\frac{p_s}{p_1} \right)^\gamma \left\{ \frac{1 + r(1 - \tau_r)}{1 + \delta} \right\}^{\gamma(s-1)} C_1. \quad (2.6)'$$

Integrating equation (2.3) and using the initial and terminal conditions, $A_1 = A_{81} = 0$, caused by no intended bequests, yield the following equation:

$$\begin{aligned} & \sum_{s=1}^{80} \{1 + r(1 - \tau_r)\}^{-(s-1)} (1 + \tau_c) C_s \\ &= \sum_{s=1}^{RE} \{1 + r(1 - \tau_r)\}^{-(s-1)} (1 - \tau_w - \tau_p) we_s + \sum_{s=ST}^{80} \{1 + r(1 - \tau_r)\}^{-(s-1)} b_s + \{1 + r(1 - \tau_r)\}^{-29} a_{30}. \end{aligned}$$

To derive C_1 , equation (2.6)' is substituted into this life-cycle budget constraint. Thus, we can find an optimum solution for C_1 .

Appendix 2.B

We investigate how the simulation results depend on the given parameter values. Table 2.5 presents the simulation results for the sensitivity analysis in the current benchmark case A. When the parameter values in the utility and production functions change, we evaluate how the results will be changed.

Table 2.5 suggests that the simulation results in the steady state are substantially dependent on the given parameters. A slight change in the parameter of intertemporal elasticity of substitution, γ , especially affects the results. When γ is low, individuals prefer a smooth plan on intertemporal consumption, regardless of their life-cycle pattern of income: the borrowing period in their lifetime lengthens, resulting in a low

level of capital stock. On the other hand, when γ is high, individuals prefer to change intertemporal consumption in accordance with the variations of income: the borrowing period shortens, resulting in a high level of capital stock.

When the adjustment coefficient for discounting the future, δ , is high, individuals prefer to consume in their earlier period a large part of their lifetime income: this leads to a decrease in capital accumulation (see Homma *et al.* (1987b) for further details).

Table 2.1 *Estimation of the age-profile of earnings ability*

a_0	a_1	a_2	a_3	a_4
-0.1537 (-0.5363)	0.05539 (2.865)	-0.0007595 (-4.019)	0.1045 (4.823)	-0.001901 (-3.243)

$$\begin{cases} S.E. = 0.02003 \\ R^2 = 0.997 \end{cases}$$

Table 2.2 *Parameter values used in simulation analysis*

	Parameter values
Adjustment coefficient for discounting the future	$\delta = -0.025$
Intertemporal elasticity of substitution	$\gamma = 0.2$
Elasticity of substitution in production	$\sigma = 0.6$
Weight parameter in production	$\varepsilon = 0.2$
Scale parameter in production	$B = 0.942$
Government expenditure per generation	$g = 0.254$
Retirement age	$RE = 40$
Replacement ratio	$\theta = 0.65$
Starting age for receiving public pension	$ST = 65$

Table 2.3 *Empirical results caused by different policies of an interest income tax (in the current steady state)*

<i>Case</i>	A	A-1	A-2	A-3	A-4
Tax rate on labor income (τ_w)	*0.07	0.094	0.046	*0.07	*0.07
Tax rate on interest income (τ_r)	*0.20	*0	*0.40	*0	*0.40
Tax rate on consumption (τ_c)	0.050	*0.05	*0.05	0.074	0.024
Capital-labor ratio (K/L)	2.98	3.03	2.86	3.21	2.69
Income-labor ratio (Y/L)	1.11	1.11	1.10	1.12	1.10
Capital-income ratio (K/Y)	2.68	2.73	2.59	2.87	2.45
Interest rate (r)	0.040	0.039	0.042	0.035	0.046
Wage rate (w)	0.989	0.993	0.982	1.003	0.971
Contribution rate (τ_p)	0.191	0.191	0.191	0.191	0.191
Amount of public pension benefit (b_s)	1.61	1.61	1.60	1.63	1.58
Bequest amount (a_{30})	4.33	4.96	3.64	5.09	3.48
Utility level (U)	-3.813	-3.868	-3.842	-3.745	-3.948
Initial consumption level (C_1)	1.26	1.21	1.30	1.24	1.27
Discount rate $\{1+r(1-\tau_r)\}$	1.032	1.039	1.026	1.036	1.028
Lifetime income	50.2	42.0	60.0	46.9	54.2

Note: Asterisks (*) before the rate indicate that the variable is exogenous.

Table 2.4 *Empirical results caused by different financial methods to cover the increased tax burden in a transition to an aging society, and by different policies of an interest income tax (in an aged steady state)*

<i>Case</i>	B	C	D	D-1	D-2
Tax rate on labor income (τ_w)	0.089	*0.07	*0.07	*0.07	0.044
Tax rate on interest income (τ_r)	*0.2	0.347	*0.2	*0	*0.4
Tax rate on consumption (τ_c)	*0.05	*0.05	0.069	0.093	*0.069
Capital-labor ratio (K/L)	2.63	2.54	2.78	3.05	2.64
Income-labor ratio (Y/L)	1.09	1.09	1.10	1.11	1.09
Capital-income ratio (K/Y)	2.40	2.33	2.52	2.74	2.42
Interest rate (r)	0.048	0.050	0.044	0.038	0.047
Wage rate (w)	0.967	0.960	0.977	0.993	0.968
Contribution rate (τ_p)	0.303	0.303	0.303	0.303	0.303
Amount of public pension benefit (b_s)	1.57	1.56	1.59	1.62	1.57
Bequest amount (a_{30})	3.85	3.32	3.94	4.70	3.22
Utility level (U)	-7.892	-7.750	-7.510	-7.317	-7.406
Initial consumption level (C_1)	1.02	1.05	1.04	1.03	1.09
Discount rate $\{1 + r(1 - \tau_r)\}$	1.039	1.033	1.036	1.039	1.029
Lifetime income	35.8	41.4	39.8	37.9	48.2

Note: Asterisks (*) before the rate indicate that the variable is exogenous.

Table 2.5 *Sensitivity analysis*

	K	Y	r	w	τ_c
<i>Benchmark</i>	356.6	132.9	4.0%	0.989	5.0%
γ 0.15	281.7	129.3	5.6%	0.945	5.2%
0.25	408.9	134.8	3.2%	1.013	5.0%
δ -0.03	391.1	134.2	3.5%	1.005	5.0%
-0.02	325.5	131.6	4.6%	0.973	5.1%
σ 0.55	339.5	131.0	3.7%	0.987	5.4%
0.65	372.7	134.8	4.3%	0.991	4.6%
ε 0.15	313.7	126.0	3.4%	0.962	6.2%
0.25	398.6	141.0	4.6%	1.023	3.8%

Note: Parameter values in the benchmark case A are $\gamma = 0.2$, $\delta = -0.025$, $\sigma = 0.6$, and $\varepsilon = 0.2$.

Figure 2.1 *Age-profiles of consumption in Cases A-1 (with a 0-percent interest income tax) and A-2 (with a 40-percent interest income tax)*

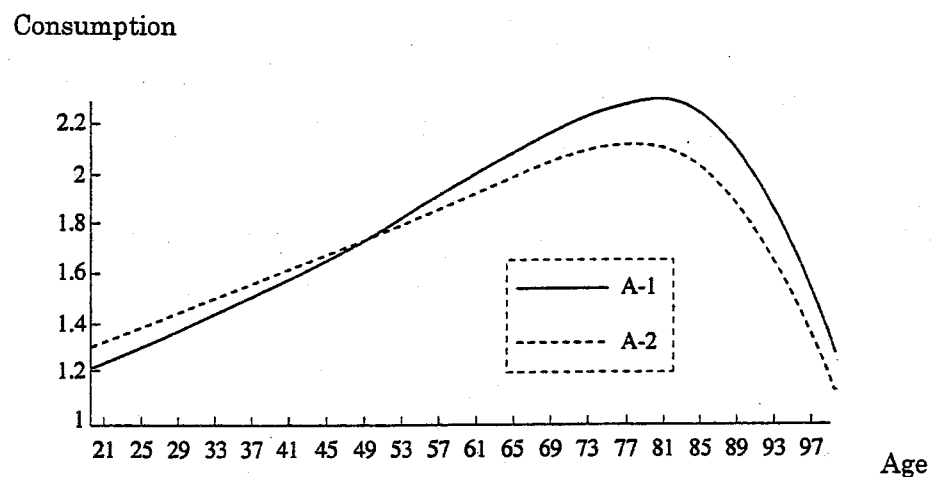


Figure 2.2 *Age-profiles of consumption in Cases A-3 (with a 0-percent interest income tax) and A-4 (with a 40-percent interest income tax)*

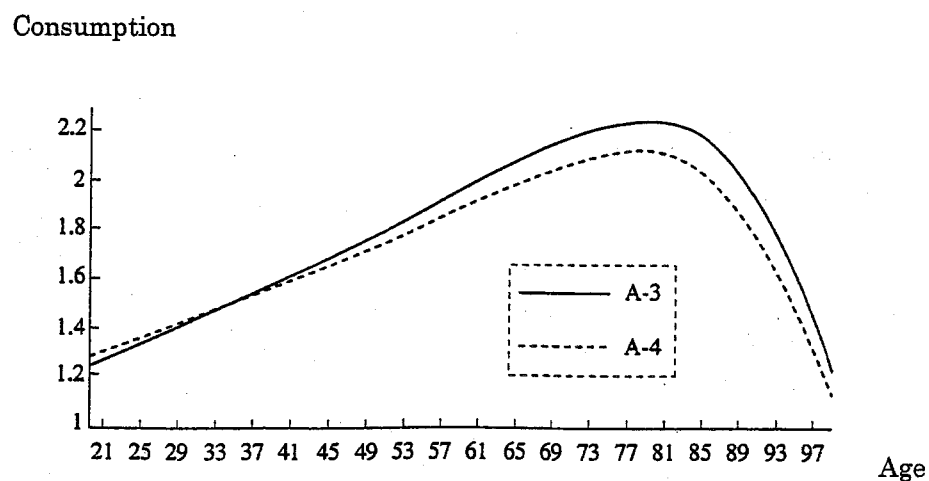


Figure 2.3 *Age-profiles of consumption in Cases B (with a 20-percent interest income tax) and C (with a 34.7-percent interest income tax)*

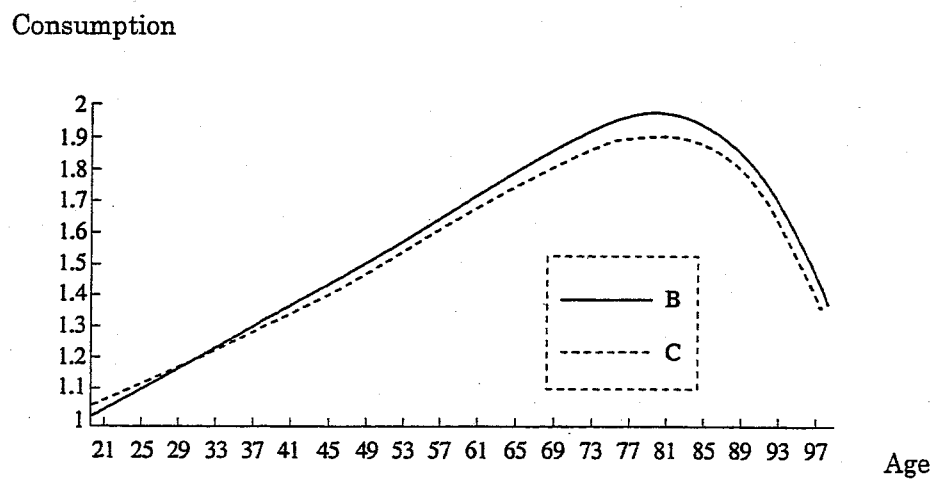
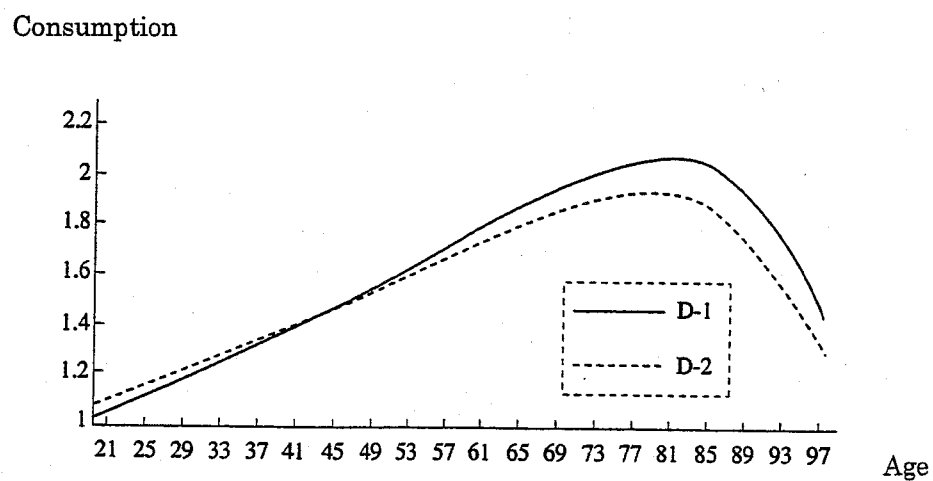


Figure 2.4 *Age-profiles of consumption in Cases D-1 (with a 0-percent interest income tax) and D-2 (with a 40-percent interest income tax)*



3 Progressive taxes and intragenerational redistribution in an aging Japan*

The life-cycle general equilibrium simulation model in the previous chapter incorporated a single representative household. Therefore, Chapter 2 fails to take account of one important aspect, namely, intragenerational redistribution. In this chapter we incorporate three representative households with unequal incomes into the simulation model. This enables us to address the problem of within-cohort inequality. Progressive labor income taxation and progressive consumption (or expenditure) taxation are discussed in this chapter, and the method of modeling progressive taxation is explained. The chapter also demonstrates how progressive taxes affect capital formation and intragenerational redistribution. Thus, it compares these two tax regimes in terms of efficiency and equity.

3.1 Introduction

The rapidly aging Japanese population will have various impacts on economic and social variables. Tax reforms accommodating this drastic structural change have become an urgent policy issue. There has been increasing discussion recently about tax

* An early version of this chapter was presented at the *1995 Annual Meeting of the Japan Fiscal Science Association (Nihon Zaisei Gakkai)* held at Okayama University, and at the Econometrics Conference at Tezukayama University in the same year. I am grateful for insightful comments and suggestions by Professors Toshiaki Tachibanaki, Naosumi Atoda, Yoshibumi Aso, Masahiro Hidaka, Takao Fujimoto, and from the seminar participants. I also acknowledge the financial support from The Yamada Foundation for Studies on Economics and Finance.

reforms in an aging Japan. Of the many studies that addressed the problem of an aging population, nearly all analyzed the effects of an aging population on production and consumption, and thus on economic growth. However, it is vital to evaluate not only efficiency but also equity.

The purpose of this chapter is to explore an optimum tax regime in an aging Japan, in terms of efficiency and equity. This chapter will examine the quantitative effects of different tax systems such as progressive labor income taxation or progressive consumption taxation, on capital accumulation and intragenerational redistribution. We employ an extended life-cycle general equilibrium simulation model of overlapping generations, with the introduction of uncertainty regarding the length of individual life and unintended bequests.

There are three themes in this chapter.

First, a major contribution to the literature is the incorporation of the difference in lifetime earnings ability into a life-cycle general equilibrium model. Many studies, such as Auerbach and Kotlikoff (1987), Homma *et al.* (1987a), or Arrau (1992), investigated the problems with an aging society using this kind of model. Nearly all of them, however, ignore the problem of intragenerational equity, namely redistribution of resources among the households that belong to the same cohort. The studies published specify the behavior of a single representative individual, and therefore it is impossible to deal with intragenerational income redistribution. As progressive taxation is likely to mitigate the inequality of resource distribution, it is crucial to allow for the difference in earnings ability.

This chapter incorporates the difference by assuming that each cohort has three representative individuals with equal tastes but unequal labor endowments, corresponding to three income classes: low, medium, and high.¹ Hence, this model enables us to investigate both efficiency and equity issues. Since our study simulates the effects of various tax reforms on efficiency and equity, it should present comprehensive and useful guidelines for tax reform.

Second, we incorporate a more realistic bequest transfer than earlier studies, for example, Iwamoto (1990), Atoda and Kato (1993), and Kato (1998). Their model incorporates unintended bequests caused by uncertainty regarding the length of an individual's life. The bequests, which were held as assets by deceased households, are handed to surviving 50-year-old households. This chapter differs from previous works in the method that follows. In the earlier studies, the inheritance is assumed to be transferred within the whole society. However, the range of inheritance in their research is too large. This chapter assumes that the bequest is transferred within each of the three income classes. Compared with the earlier studies, the bequest transfer is thus closer to reality. The difference in the amount of bequests received across the income classes reflects the difference in lifetime earnings ability. This permits us to conduct analysis in a model with a greater similarity to the real world.

Third, the role of progressive consumption taxation is discussed. Progressive consumption taxation used here is a direct tax that is levied on consumers. Hence, it may be appropriate to call it "progressive expenditure taxation." Few studies have dealt with this new type of tax scheme to evaluate the effects of structural tax reforms. Since there are only a few studies on progressive expenditure taxation, our analysis has some merit as a pioneering work. Progressive expenditure taxation will be evaluated in comparison with progressive labor income taxation, in terms of efficiency and equity.

This chapter is organized as follows: Section 3.2 identifies the basic model employed in simulation analysis. Section 3.3 explains the method of simulation analysis and the assumptions adopted. Section 3.4 evaluates the simulation findings. Section 3.5 summarizes and concludes the chapter.

3.2 Theoretical framework

We calibrate the simulation of the Japanese economy by employing population data estimated by the Institute of Population Problems of the Ministry of Health and

Welfare in 1992. The model has 75 different overlapping generations. Three types of agents are considered: households, firms, and the government. The basic structure of them is explained in order, and market equilibrium conditions are finally presented.

3.2.1 Household behavior

Households are divided into three income classes: low, medium, and high. A single household type represents each income class. Each household has the same mortality rate and the same utility function. Unequal labor endowments, however, create different income levels. Each household appears in the economy as a decision-making unit at the age of 21 and lives to a maximum of 95.² Households face an age-dependent probability of death. Let $q_{j+1|j}$ be the conditional probability that a household of age $j + 20$ lives to $j + 21$. Then the probability of a household of age 21 surviving until $s + 20$ can be expressed by

$$p_s = \prod_{j=1}^{s-1} q_{j+1|j} . \quad (3.1)$$

The probability $q_{j+1|j}$ is calculated from data estimated in 1992 by the Institute of Population Problems of the Ministry of Health and Welfare.

The utility of each household depends only on the level of consumption. There is no choice between leisure and labor supply. Each household works from age 21 to $RE + 20$, the retirement age. The labor supply is inelastic and after retirement is zero. Each household that maximizes expected lifetime utility makes lifetime decisions at age 21 concerning the allocation of wealth between consumption and savings. The utility function of a representative household, whose form is assumed to be time-separable, is

$$U^i = \frac{1}{1 - \frac{1}{\gamma}} \sum_{s=1}^{75} p_s (1 + \delta)^{-(s-1)} \{C_s^i\}^{1 - \frac{1}{\gamma}} , \quad (3.2)$$

where C_s^i represents consumption (or expenditure) at age $s + 20$, δ the adjustment coefficient for discounting the future, and γ the intertemporal elasticity of

substitution between consumption in different years. The superscript $i (=l, m, h)$ stands respectively for low, medium, and high-income class.

The flow budget constraint equation for each household at age $s + 20$ is

$$A_{s+1}^i = \{1 + r(1 - \tau_r)\} A_s^i + \{1 - \tau_w(wx^i e_s) - \tau_p\} wx^i e_s + b_s^i + a_s^i - \{1 + \tau_c(C_s^i)\} C_s^i, \quad (3.3)$$

where A_s^i represents the amount of assets held by the household at the beginning of age $s + 20$, r the interest rate, w the wage rate per efficiency unit of labor, and e_s the age-profile of earnings ability for the household that belongs to the medium income class.³ b_s^i is the amount of public pension benefit, and a_s^i is the amount of bequest to be inherited at age $s + 20$. $\tau_w(wx^i e_s)$ is the tax rate on labor income, $\tau_c(C_s^i)$ that on consumption, τ_r that on interest income, and τ_p is the contribution rate to public pension system. x^i is the weight coefficient corresponding to the different levels of labor endowments among the three income classes. The medium income class is used as a yardstick, and thus $x^m = 1$. x^l and x^h reflect the realistic difference of lifetime earnings ability across the three income classes.

The tax system consists of labor income, interest income, and consumption taxes. Labor income or consumption (i.e., expenditure) is taxed progressively. The progressive tax schedule is incorporated in the same manner as in Auerbach and Kotlikoff (1983a, 1987). If the tax base is z , we choose two parameters labeled α and β , and set the average tax rate (τ_w or τ_c) equal to $\alpha + \frac{1}{2}\beta z$ for all values of z . The corresponding marginal tax rate ($\overline{\tau_w}$ or $\overline{\tau_c}$) is $\alpha + \beta z$. Setting $\beta = 0$ amounts to proportional taxation. One may make the tax system more progressive, holding the revenue constant, by increasing β and decreasing α simultaneously.

Progressive taxation is applied to the gross wage rate or the level of consumption on an annual basis for households. In the case of progressive labor income taxation, the tax base, z , is the gross wage rate, $wx^i e_s$. If progressive expenditure (or consumption) taxation is adopted, z is the level of expenditure (or consumption), C_s^i . The symbols, $\tau_w(wx^i e_s)$ and $\tau_c(C_s^i)$, in equation (3.3) mean that τ_w and τ_c are respectively functions of $wx^i e_s$ and C_s^i . The tax system for interest income is based

on proportional taxation.⁴

Variables related to the public pension program in a pay-as-you-go system are represented by

$$\begin{cases} b_s^i = \theta H^i & (s \geq ST) \\ b_s^i = 0 & (s < ST) \end{cases}, \quad (3.4)$$

where the age at which each household starts to receive public pension benefits is $ST + 20$, the average annual remuneration is $H^i \left(= \frac{1}{RE} \sum_{s=1}^{RE} wx^i e_s \right)$, and the replacement ratio is θ . Thus b_s^i reflects the difference of lifetime earnings ability across the three income classes.

There are unintended bequests caused by uncertainty regarding the length of life. The bequests, which were held as assets by deceased households, are handed to surviving 50-year-old households. Therefore a_s^i is positive if and only if $s = 30$, and otherwise zero. The inheritance is transferred within households that belong to the same income class. When BQ_t^i is the sum of bequests inherited by 50-year-old households at period t , a_{30}^i is defined by

$$a_{30}^i = \frac{BQ_t^i}{N_t p_{30} (1+n)^{-29}}, \quad (3.5)$$

where

$$BQ_t^i = N_t \sum_{s=1}^{75} (p_s - p_{s+1}) (1+n)^{-(s-1)} A_{s+1}^i,$$

N_t is the number of new households entering the economy as decision-making units at period t , and n is the common growth rate of successive cohorts.

Let us consider the case in which each household maximizes its lifetime utility under a constraint. Each household maximizes equation (3.2) subject to equation (3.3) (see Appendix 3.A). From the utility maximization problem, the equation expressing evolution of consumption over time for each household is characterized by

$$C_{s+1}^i = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \left(\frac{1+\bar{\tau}_c(C_s^i)}{1+\tau_c(C_{s+1}^i)} \right) \right]^{\gamma} C_s^i. \quad (3.6)$$

This equation represents the impact of progressive expenditure taxation on household

behavior. If initial consumption level, C_1^i , is specified, optimal consumption behavior of all ages can be calculated from equation (3.6). The amount of assets held by each household at each age can be obtained from equation (3.3). The expected lifetime utility of each household is derived from equation (3.2).

The social welfare function, which takes into account heterogeneity in labor forces, is given by

$$SW = U^l + U^m + U^h. \quad (3.7)$$

This function is obtained by a simple summation of the expected utilities of the three income classes. The function is of a "Benthamite type," but depends mainly on the utility of the low-income class, like a "Rawlsian type." The function is maximized if all income classes have the same level of consumption.⁵

3.2.2 Firm behavior

The model has a single production sector that is assumed to behave competitively using capital and labor, subject to a constant-returns-to-scale production function. Capital is homogeneous and non-depreciating, while labor differs only in its efficiency. All forms of labor are perfect substitutes. Households in different income classes or of different ages, however, supply different amounts of some standard measure per unit of labor input.

The production function is assumed to be of the constant elasticity of substitution form:

$$Y_t = B \left[\varepsilon K_t^{1-\frac{1}{\sigma}} + (1-\varepsilon) L_t^{1-\frac{1}{\sigma}} \right]^{\frac{1}{1-\frac{1}{\sigma}}}, \quad (3.8)$$

where Y_t represents the total output, K_t the total capital, L_t the total labor supply measured by the efficiency units, B a scaling constant, ε a parameter measuring the intensity of use of capital in production, and σ the elasticity of substitution between K_t and L_t . Using the property subject to a constant-returns-to-scale production function, we can obtain the following equation:

$$Y_t = rK_t + wL_t. \quad (3.9)$$

3.2.3 Government behavior

The government sector consists of a narrower government sector and a pension sector. The narrower government sector collects taxes and spends them on general governmental expenditure. There is no outstanding debt, and thus balanced budget policies are assumed. The budget constraint of the narrower government sector at time t is given by

$$G_t = T_t, \quad (3.10)$$

where G_t is government spending on goods and services in year t , and T_t is the total tax revenue from labor income, interest income, and consumption.

The public pension system is assumed to be a simple pay-as-you-go style. The budget constraint of pension sector at time t is given by

$$R_t = B_t, \quad (3.11)$$

where R_t is the total contributions to the pension scheme, and B_t is the total pension benefits to generations of age $ST + 20$ and above.

Both of these sectors are financed independently and separately. No transfer is made between the sectors. G_t , T_t , R_t , and B_t are defined respectively by

$$G_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} 3g, \quad (3.12)$$

$$T_t = LX_t + \tau_r rAS_t + CX_t, \quad (3.13)$$

$$R_t = \tau_p wL_t, \quad (3.14)$$

$$B_t = N_t \sum_{s=ST}^{75} p_s (1+n)^{-(s-1)} \{b_s^l + b_s^m + b_s^h\}, \quad (3.15)$$

where g is government expenditure per income class within each cohort. LX_t and CX_t are tax revenues from labor income and consumption, respectively. This chapter assumes that each income group accounts for a third of the population. Thus, the tax revenue can be obtained through a summation for the three income classes with the same weight:

$$LX_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} \left[\alpha w x^l e_s + \frac{1}{2} \beta (w x^l e_s)^2 + \alpha w x^m e_s + \frac{1}{2} \beta (w x^m e_s)^2 + \alpha w x^h e_s + \frac{1}{2} \beta (w x^h e_s)^2 \right], \quad (3.16)$$

$$CX_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \left[\alpha C_s^l + \frac{1}{2} \beta (C_s^l)^2 + \alpha C_s^m + \frac{1}{2} \beta (C_s^m)^2 + \alpha C_s^h + \frac{1}{2} \beta (C_s^h)^2 \right]. \quad (3.17)$$

Similarly, equation (3.15), aggregate assets supplied by households AS_t , and aggregate consumption AC_t are obtained by a simple summation for the three classes:

$$AS_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \{A_s^l + A_s^m + A_s^h\}, \quad (3.18)$$

$$AC_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \{C_s^l + C_s^m + C_s^h\}. \quad (3.19)$$

3.2.4 Market equilibrium

Finally, equilibrium conditions for the capital, labor, and goods markets are described.

1 Equilibrium condition for the capital market

Since aggregate assets supplied by households are equal to real capital, we get

$$AS_t = K_t. \quad (3.20)$$

2 Equilibrium condition for the labor market

Measured in efficiency units, since aggregate labor demand by firms is equal to aggregate labor supply by households, we get

$$L_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} \{x^l + x^m + x^h\} e_s. \quad (3.21)$$

3 Equilibrium condition for the goods market

As aggregate production is equal to the sum of consumption, investment, and government expenditures, we get

$$Y_t = AC_t + (K_{t+1} - K_t) + G_t. \quad (3.22)$$

An iterative program is performed to obtain the equilibrium values of the above equations.

3.3 Simulation analysis

3.3.1 Method of simulation

The simulation model presented in the previous section is solved under a hypothesis of perfect foresight by households. Households correctly anticipate the interest, wage, and tax rates. If tax and public pension systems are determined, the model can be solved using the Gauss-Seidel method (see Appendix 3.B for the computation process).

We consider two steady states, namely, the 1995 current state and the aged state projected for 2025. To ascertain the clear effects of structural tax reforms, tax revenue neutrality is assumed. This model holds that tax revenue is constant across all the simulation cases in the method that follows. Across all cases, the size of population is the same and the government expenditure per representative household, g , is constant and exogenously given. Therefore, the total tax revenue, T_t , is exogenous and the same across all simulations.⁶ The value of N_t (new entrants in the model in period t) is chosen to make the number of households equal between the current and aged steady states.

Different growth rates of successive cohorts, n , and different survival probabilities, p_s , create different age structures of the population between the current and aged states. Japan faces a decline in the proportion of the working population in a transition to an aging society, with a subsequent decrease in aggregate output; hence, the ratio of the total tax revenue to aggregate output rises, which substantially increases the tax burden in the aged states. A consumption tax covers this tax burden that increases with an aging population.⁷

As for the tax system, the tax rates on labor income, $\tau_w(wx^i e_s)$, and consumption, $\tau_c(C_s^i)$, are exogenously given. Under tax revenue neutrality, the tax rate on interest income, τ_r , is made endogenous. As for the public pension system, the replacement ratio, θ , is exogenously given, and hence, the contribution rate, τ_p , is made endogenous under the pay-as-you-go scheme.

3.3.2 Simulation cases

Table 3.1 presents the simulation cases. Case A is the current benchmark of 1995; the tax system on labor income has a realistic progressiveness.⁸ Tax rates on interest income and consumption are 20 and 5 percent, respectively. If in Case A, a proportional labor income tax replaces a progressive one, this case is then labeled Case A-1. If in Case A-1, a progressive consumption tax replaces a proportional one, this case is then labeled Case A-2. Cases B, B-1, and B-2 correspond respectively to Cases A, A-1, and A-2. The only difference is in the population structure: Case B considers an aging society projected for 2025. The degree of tax progressivity on labor income in Case B is the same as that in Case A, and the tax rate on interest income remains 20 percent.

Progressive taxation has two effects. The first and obvious effect is that it changes the tax burdens of the low, medium, and high-income classes. Relative to a proportional base, it decreases the tax burden of the low-income class, while it increases that of the high-income class. The second effect is a change in the time path of taxation during an individual's life cycle. A progressive labor income tax changes the age-profile of after-tax labor income. A progressive consumption tax provides different tax rates in proportion to the level of consumption during an individual's life cycle.

Four additional cases, A*, A-2*, B*, and B-2*, are examined to analyze the size of the first effect (different tax burdens) and the second effect (different time paths of taxation during an individual's life cycle) in a quantitative way. These four cases have only the former effect. In Cases A* and B*, for each income class, the annual tax burden on labor income is the same as that in Cases A and B (progressive taxation cases). In Cases A* and B*, the shape of the age-profile of after-tax labor income is not affected by progressive taxation, and thus it is the same as that of the age-profile of earnings ability. In these cases, for each income class, a constant tax rate on labor income is chosen under revenue neutrality. This method is also applied in the case of a progressive consumption tax.

3.3.3 Specification of parameters

This chapter examines the implications of tax policies for an aging Japanese economy. As indicated in Table 3.2, we choose parameter values realistic for the economy. In Case A (current benchmark), economic variables such as the ratios of capital to income (K/Y) and capital to labor (K/L) are close to actual values of 1995.

Table 3.1 presents the parameter values that characterize the two steady states. Survival probabilities (p_s) are calculated from the *Population Projections for Japan 1991-2090*. Our model makes no sex distinction, and so this study uses the male-female average values for 1995 and 2025. The proportions of aged population (65 or above) to the total population (21 or above) in 1995 and 2025 are 19.2 and 32.8 percent, respectively, based on the above estimates. The growth rate of successive cohorts (n) is chosen so that the ratios in the simulation are the same as the estimated values. Parameters on the public pension program are set close to actual values of 1995. The replacement ratio of pension payments (θ) is adjusted so that the contribution rate equals the 1995 rate of 16.5 percent in employees' pension plans (*Kosei Nenkin*).

The weights given to labor endowments for each income class and the degree of tax progressivity are explained. We use data that includes all ranges of individual income taxes by adding two sources: data for income tax collected at the tax office; and data for self-assessed income tax. The data is based on the *Statistical Year Dissertation of National Taxes (Kokuzeicho Tokei-Nenposho) 1994*. Table 3.3 shows the number of people in the low, medium, and high-income classes; and the ratios of the amount of income for each income class that accounts for one third of the population. The weight parameter on the lifetime earnings ability for each income class is set based on this data.

Parameters that determine the degree of tax progressivity on labor income in Case A are chosen so that for the three income classes, the ratios of tax revenue from labor income in the simulation are the same as the ratios indicated in Table 3.3. Parameters

that determine the degree of tax progressivity on consumption in Case A-2 are adjusted so that the degree is the same as in Case A. Between progressive labor income taxation and progressive consumption taxation, it is difficult to make the degree of tax progressivity identical. Hence, we decided to keep the tax revenue (i.e., the sum of revenue from the three tax bases) for each income class identical between these two cases (see Table 3.1 for the assignment of parameter values, α and β).

3.4 Simulation results

3.4.1 Findings and their interpretation

Table 3.4 presents the simulation results caused by progressive labor income taxation and progressive consumption taxation. In this chapter, the influence on capital accumulation is regarded as an indicator of efficiency. This is because under the assumption of an inelastic labor supply, the level of the total output depends only on the level of capital stock, as indicated by equation (3.8). Social welfare is evaluated by the function represented by equation (3.7). It should be noted that the social welfare function reflects not only the aspect of equity but also that of efficiency.

1 The influence of progressive labor income taxation

Cases A and A-1 represent respectively the cases of progressive labor income taxation and proportional taxation. To analyze the impacts of progressive labor income taxation, we consider the transfer from Case A-1 to A. The capital-labor ratio (K/L) increases from 2.781 to 2.851. Social welfare improves from -82.971 to -67.304. The utility of the low income class is ameliorated from -79.109 to -63.865. On the other hand, the utility of the high income class is deteriorated from -0.153 to -0.166.

2 The influence of progressive consumption taxation

Case A-2 represents the case of progressive consumption taxation. To study the impacts of this taxation, we consider the move from Case A-1 to A-2. The capital-labor ratio (K/L) increases to 2.845, and social welfare improves to -70.538. The utility

level of the low income class increases to -67.001, while the level of the high income class diminishes to -0.161. Therefore, under the assumption of an inelastic labor supply, the transition from proportional to progressive taxation raises the capital-labor ratio (K/L). This leads to a higher level of social welfare.

(1) Evaluation of the two tax regimes in terms of efficiency

As explained in the previous section, progressive taxation provides two effects: it changes the tax burdens among the low, medium, and high-income classes; and it also changes the time path of taxation during an individual life cycle.

Progressive labor income taxation changes the time path of after-tax labor income under a pay scale based on seniority. In Case A*, this change in Case A (progressive tax case) is removed. In Case A*, for each income class, a proportional tax rate on labor income is chosen so that the class's tax revenue from labor income is the same as in Case A. Thus, the time path of after-tax labor income is the same between Case A* and Case A-1 (proportional tax case). Aggregate capital of 1041.8 is also the same between these cases. This result suggests that the change in the tax burden among the three income classes has no influence on capital formation, because the utility function of each income class is identical. Therefore, we find that an increase in the capital stock depends on a change in the time path of after-tax labor income regarding an individual life cycle. This may be called the "capital increasing effect."

Progressive consumption taxation provides different tax rates on consumption in each age under an age-profile of consumption with an upward slope. In Case A-2*, this property in Case A-2 (in which the tax rate on consumption varies with a level of consumption in each age) is ruled out. In Case A-2*, for each income class, a constant tax rate on consumption replaces a progressive one to cover the class's tax revenue from consumption in Case A-2. Figure 3.1 suggests that the age-profile of consumption is gentler and lower in Case A-2 than in Case A-2*. Aggregate capital of 1041.8 is the same between Cases A-2* and A-1. Thus, the change in the tax burden on consumption among the three income classes has no influence on capital accumulation.

The change in the time path of taxation on consumption stimulates capital formation. In both progressive labor income taxation and progressive consumption taxation, this "capital increasing effect" arises from the change in the timing of taxation during an individual's life cycle. This effect is caused mainly by a decrease in borrowing during the younger periods in these tax regimes. Under progressive labor income taxation, young households have low tax rates on labor income due to a low level of labor income. This may account for a large part of the "capital increasing effect" (see Figure 3.2 for the difference in the age-profiles of assets for the high-income class in Cases A and A*). Similarly, under progressive consumption taxation, young households have low tax rates on consumption because of a low level of consumption. This may also provide the "capital increasing effect" (see Figure 3.3 for the difference in the age-profiles of assets for the high-income class in Cases A-2 and A-2*).

It should be noted that the effect on the assets of the high-income class is the opposite between progressive labor income taxation and progressive consumption taxation. When progressive labor income taxation is incorporated (i.e., in the moving from Case A-1 to A), the assets of the high-income class decrease from 627.6 to 606.0. On the other hand, when progressive consumption taxation is introduced (i.e., in the transferring from Case A-1 to A-2), the assets increase to 649.0. The result on progressive labor income taxation may be predictable. The introduction of progressive taxation reduces aggregate consumption of the high-income class and thus diminishes their assets, which have been accumulated for future consumption.

The result about progressive consumption taxation does not seem so easy to predict. This is because the "capital increasing effect" of progressive taxation is remarkable for the high-income class. Due to a property of progressive taxation, the change in the tax rate during an individual's life cycle is more striking for the high-income class than for the low. In the case of progressive consumption taxation (A-2), for the high-income class the lifetime range of the tax rate on consumption is from 5.1 percent to 8.8 percent, while the range for the low-income class is small from

0.5 percent to 1.3 percent. Since the assets of the high-income class account for a large part of the capital stock, the “capital increasing effect” on the high-income class makes a substantial contribution to capital formation in Case A-2.

(2) Evaluation of the two tax regimes in terms of equity

We establish the effects of progressive labor income taxation and progressive consumption taxation on social welfare. In the current steady state, the highest level of social welfare is attained in Case A (progressive labor income taxation) with -67.304. Then comes Case A-2 (progressive consumption taxation) with -70.538, and finally Case A-1 (proportional taxation) with -82.971. In the aged steady state, we also obtain the same qualitative effect. The simulation result suggests that when labor income is taxed progressively, the redistribution effect is greater. This may be because households cannot control the age-profile of labor income in our model, which seems true for Japan. In this respect, progressive labor income taxation would cause a greater distortion on household behavior, although it has a substantial redistribution effect.

On the other hand, since households can control the age-profile of their consumption, the redistribution effect may be weaker when consumption is taxed progressively; in the case of progressive consumption taxation, there is some room for households to avoid high tax rates on consumption. Figure 3.1 suggests that under progressive consumption taxation, the age-profile of consumption becomes gentler and lower (see equation (3.6) for the time path of consumption distorted under progressive consumption taxation).

In the aged steady state, we obtain the qualitatively similar results to those in the current steady state (see Table 3.4 for the simulation results in the aged-state cases).

3.4.2 Comments

The following three comments need to be noted for interpreting the simulation results.

First, they show that progressive taxation promotes capital accumulation.

However, this may depend on the inelastic labor supply that is one of the assumptions in our model. As labor supply is exogenous, the effect of progressive taxation on income comes only from the savings. Given the age-profiles of labor income or consumption with an upward slope as in our study, progressive taxes increase savings and thus income. If the relationship between tax progressivity and labor supply incentive were explicitly taken into account, progressive taxation would not always give favorable outcomes (see Appendix 3.C for further details of progressive taxation). Since we address the Japanese economy, our simulation has some significant policy implications.⁹

Second, cross-section data is employed in the estimation of the difference in lifetime earnings ability among households within a cohort. The data presented in Table 3.3 includes all age groups: young, middle, and old. Therefore, the estimated value of the variance concerns income distribution not of people who belong to the same cohort, but of all people who exist in the economy at a point in time (1994). So-called panel data, which traces people within a cohort for a long period, should have been used for the purpose of our study. However, this kind of data is not presently available in Japan, and thus the cross-section data was employed as a second best source.¹⁰

The difference in earnings ability, based on educational backgrounds, may also account for differences in the ability of labor supply. It is vital to understand how the simulation results would be revised, if this alternative indicator were adopted as the difference in lifetime earnings ability. We conducted simulation analyses that incorporate differences based on educational backgrounds (see Appendix 3.D for further details). In that case, the difference in labor endowments is smaller than that adopted in this chapter.

Finally, all income classes are identical in our simulation model including the utility function, except for earnings ability. Empirical evidence such as Hausman (1979) and Lawrence (1986), however, suggests that the rate of time preference may be

substantially higher for low-income individuals. If this difference in the rate of time preference among representative households were introduced, the simulation results would be different. Similarly, the difference in the intertemporal elasticity of substitution, γ , among them would also revise the results (see Appendix 3.E for further details).¹¹

3.5 Conclusions

This chapter has examined the effects of progressive labor income taxation and progressive consumption taxation on efficiency and equity in Japan, where the population is undergoing an aging trend. To analyze this situation, we employed a simulation approach for the extended life-cycle general equilibrium model of overlapping generations, with the difference in the ability of labor supply. Three major conclusions have been drawn from the simulation.

First, compared with proportional taxation, progressive taxation has the “capital increasing effect,” as households accumulate more assets to maximize their lifetime utilities. This is verified if progressive labor income taxation is implemented under a pay scale based on seniority, or if progressive expenditure taxation is introduced under the age-profile of consumption with an upward slope. This “capital increasing effect” is caused by changing the timing of taxation to occur later in a life cycle, when labor income or expenditure grows over the lifetime.

Second, progressive labor income taxation and progressive consumption taxation give different effects on assets of the high-income class. Under progressive labor income taxation assets of the high-income class decrease, while under progressive consumption taxation they increase. Since the assets of the high-income class account for a large part of the capital stock, progressive consumption taxation substantially enhances capital formation.

Third, the simulation results suggest that under an inelastic labor supply, progressive labor income taxation generates a stronger redistribution of resources than

progressive consumption taxation: although progressive labor income taxation is preferable in terms of equity, it is likely to have a greater distortion on household behavior due to an uncontrollable labor supply. Therefore, the introduction of progressive consumption taxation seems an optimum policy for an aging Japan.

Appendix 3.A

To consider the utility maximization problem over time for each income class, namely the maximization of equation (3.2) subject to equation (3.3), let the Lagrange function be

$$L^i = U^i + \sum_{s=1}^{75} \lambda_s^i \left[-A_{s+1}^i + \{1+r(1-\tau_r)\}A_s^i + \{1-\tau_w(wx^i e_s) - \tau_p\}wx^i e_s + b_s^i + a_s^i - \{1+\tau_c(C_s^i)\}C_s^i \right]$$

where λ_s^i represents the Lagrange multiplier for equation (3.3) and superscript $i (=l, m, h)$ denotes respectively low, medium, and high income class.

The first-order conditions for $s = 1, 2, \dots, 75$ can be expressed by

$$\frac{\partial L^i}{\partial C_s^i} = p_s (1+\delta)^{-(s-1)} \{C_s^i\}^{-\frac{1}{\gamma}} - \lambda_s^i \{1+\tau_c(C_s^i)\} = 0, \quad (3.A)$$

$$\frac{\partial L^i}{\partial A_{s+1}^i} = -\lambda_s^i + \lambda_{s+1}^i \{1+r(1-\tau_r)\} = 0. \quad (3.B)$$

The combination of equations (3.A) and (3.B) yields the equation that determines the slope of the age-consumption profile over the life cycle:

$$C_{s+1}^i = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \left\{ \frac{1+\tau_c(C_s^i)}{1+\tau_c(C_{s+1}^i)} \right\} \right]^\gamma C_s^i. \quad (3.6)$$

For a given C_1^i , equation (3.6) solves the consumption path. The transformation of equation (3.6) leads to the following expression:

$$C_s^i = \left[\left(\frac{p_s}{p_1} \right) \left\{ \frac{1+\tau_c(C_1^i)}{1+\tau_c(C_s^i)} \right\} \right]^\gamma \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\}^{\gamma(s-1)} C_1^i. \quad (3.6)'$$

Integrating equation (3.3) and using the initial and terminal conditions,

$A_1^i = A_{76}^i = 0$, caused by no intended bequests, yield the following equation:

$$\sum_{s=1}^{75} \{1+r(1-\tau_r)\}^{-(s-1)} [1+\tau_c(C_s^i)] C_s^i$$

$$= \sum_{s=1}^{RE} \{1+r(1-\tau_r)\}^{-(s-1)} [1-\tau_w(wx^i e_s) - \tau_p] wx^i e_s + \sum_{s=ST}^{75} \{1+r(1-\tau_r)\}^{-(s-1)} b_s^i + \{1+r(1-\tau_r)\}^{-29} a_{30}^i$$

To derive C_1^i , equation (3.6)' is substituted into this lifetime budget constraint. Thus, an optimum solution for C_1^i can be obtained.

Appendix 3.B

If tax and public pension systems are determined, the simulation model presented in Section 3.2 can be solved using the Gauss-Seidel method. The outline of a computation process is as follows:

Step 1

The interest rate r^0 , the wage rate w^0 , the bequest amount for each income class $(a^i)^0$, the tax rate on interest income τ_r^0 , and the contribution rate to a public pension scheme τ_p^0 are chosen as initial values.

Step 2

Each household that maximizes the lifetime utility determines the time paths of consumption $(C^i)^1$ and savings $(S^i)^1$ for an entire life cycle, by taking the previous values and the tax rates on labor income $\tau_w(wx^i e_s)$ and consumption $\tau_c(C_s^i)$ as given.

Step 3

Aggregate capital K^1 is obtained by summing the assets of each income class across cohorts, and by adding up them $(A^i)^1$ across the three lifetime-income classes within a cohort. The production equilibrium conditions, which are derived from equation (3.8), bring about a new interest rate r^1 and a new wage rate w^1 . Each income class's total assets $(A^i)^1$ lead to the class's sum of bequests $(BQ^i)^1$, which generates a new amount of bequest $(a^i)^1$.

To balance the account of a narrower government sector, the tax rate on interest income changes to τ_r^1 . Similarly, to balance the account of a public pension sector, the contribution rate changes to τ_p^1 .

Step 4

Using r^1 , w^1 , $(a^i)^1$, τ_r^1 , and τ_p^1 as new initial values, we return to Step 1. This method is iterated until stable variables (or equilibrium) are obtained.

Appendix 3.C

In order to demonstrate in a quantitative way how the negative impact of progressive taxation on labor supply affects capital formation, sensitivity analyses were carried out for exogenous changes in labor supply.

We consider the move from the proportional case (A-1) to the progressive case (A). To allow for the disincentive effect on labor supply by the shift from proportional to progressive taxation, we exogenously diminish labor supply from 374.6 to 363.8 (2.9 percent decrease) in Case A. This case with a reduced labor supply is labeled Case A-a. Table 3.6 suggests that the level of aggregate capital of 1041.8 is the same between the progressive tax case (A-a) and the proportional tax case (A-1). This result shows that when the progressive tax decreases labor supply by 2.9 percent, the capital stock remains unchanged. We also examined the case of a 5.0 percent decrease (from 374.6 to 355.9) in labor supply by the move from Case A-1 to Case A. This case is labeled Case A-b. Table 3.6 presents that aggregate capital in the progressive case (A-b) of 1022.0 is lesser than that in the proportional case (A-1).

These simulation results indicate that if our model takes account of the negative impact of a progressive tax on labor supply, the overall influence of progressive taxation on capital formation cannot be determined *a priori*.

Appendix 3.D

The difference in lifetime earnings ability among the three income classes is estimated using the cross section data in this chapter. The difference based on educational backgrounds may also be a possible explanation for the difference in labor endowments. The estimation based on educational backgrounds was undertaken using only male

workers' data from the *Basic Survey on Wage Structure 1995* by the Ministry of Labor. This is because female workers may be a disturbance factor for our purpose, due to a high ratio of part-time workers. The estimation employs the following regression:

$$Q = a_0 + a_1N + a_2N^2,$$

where Q denotes average monthly cash earnings and N age. Monthly cash earnings used here also contain bonuses. Table 3.7 shows the estimated parameter values for junior high school, high school, junior or technical college, and university graduates. Each of them accounts for the following proportion in the population: junior high school 14.7 percent, high school 51.0 percent, junior or technical college 6.9 percent, and university graduates 27.4 percent.

Figure 3.4 presents the age-profiles of earnings ability based on educational backgrounds. This figure suggests that the gap in earnings ability is the largest between junior high school graduates and university graduates. It should be noted that the disparity between them is only the double even in the ages when the gap is the largest. This result suggests that the difference in lifetime earnings ability among households should have been more reduced, if the disparity of earnings ability based on educational backgrounds is taken into account.

As for the relationship between age and labor endowments, the difference in earnings ability among households gradually increases with age (see Appendix 7.F for the simulation analysis that considers this observation).

Appendix 3.E

In this chapter, each income class is identical including the utility function, except for labor endowments. If the rate of time preference differs among the three income classes, it may change the influence of progressive taxation on capital formation. We undertook a simulation analysis with the different rates of time preference among the classes. The adjustment coefficients for discounting the future, δ^i ($i = l, m, h$), for low, medium, and high income classes are set respectively to -0.0062, -0.0162, and

-0.0262. If the different coefficients are incorporated in Case A, this case is then labeled Case A-c. In the similar way, we set Cases A-1-c and A-2-c.

To investigate the influence of progressive labor income taxation on capital accumulation, we compare the moves from Case A-1 to Case A and from Case A-1-c to A-c. Table 3.4 presents that when the rate of time preference is the same among the three income classes, the capital stock increases from 1041.8 to 1068.1 by 2.53 percent. Table 3.8 suggests that when the rates of time preference differ among the classes, the capital stock increases from 1142.1 to 1165.8 by only 2.08 percent. This may be because progressive taxation decreases the tax burden of the low-income class who has a low propensity to save, and increases the tax burden of the high-income class who has a high propensity to save.

To examine the impact of progressive consumption taxation on capital formation, we compare the shifts from Case A-1 to A-2 and from Case A-1-c to A-2-c. Table 3.4 shows that when the rate of time preference is the same among the three income classes, the capital stock increases from 1041.8 to 1081.0 by 3.77 percent. Table 3.8 indicates that when the rates of time preference differ among the classes, the capital stock increases from 1142.1 to 1193.5 by 4.50 percent. Thus, the simulation results are contrasting result between progressive labor income taxation and progressive consumption taxation.

According to the sensitivity analysis in Appendix 2.B, a slight change in the parameter of intertemporal elasticity of substitution affects capital formation substantially. We undertook a simulation analysis with different intertemporal elasticities of substitution. The intertemporal elasticities of substitution, γ^i ($i = l, m, h$), for low, medium, and high-income classes are set respectively to 0.1, 0.2, and 0.3. If the different elasticities are introduced in Case A, this case is then labeled Case A-d. Similarly, we set Cases A-1-d and A-2-d. The simulation results presented below are similar to those in the case of the different rates of time preference:

To study the effect of progressive labor income taxation on capital accumulation,

we compare the transfers from Case A-1 to A and from Case A-1-d to A-d. When the elasticity is the same among the three classes, the capital stock increases by 2.53 percent. Table 3.9 suggests that when the elasticities of intertemporal consumption differ among the classes, the capital stock increases from 1197.7 to 1218.2 by only 1.71 percent. To evaluate the influence of progressive consumption taxation, we compare the shifts from Case A-1 to A-2 and from Case A-1-d to A-2-d. When the elasticity is the same among the three income classes, the capital stock increases by 3.77 percent. Table 3.9 shows that when the elasticities differ among the classes, the capital stock increases from 1197.7 to 1248.3 by 4.22 percent. These simulation results are also contrasting result between progressive labor income taxation and progressive consumption taxation.

Table 3.1 *Simulation cases*

1 Current steady state (1995)

Case	A (Progressive labor income tax)	A-1 (Proportional tax)	A-2 (Progressive consumption tax)	A*	A-2*
Tax rate on labor income (τ_w)	* $\begin{cases} \alpha = 0.00358 \\ \beta = 0.032 \end{cases}$	* $\begin{cases} \alpha = 0.065 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.065 \\ \beta = 0 \end{cases}$	* _(L) 0.0207 * _(M) 0.0404 * _(H) 0.0854	* $\begin{cases} \alpha = 0.065 \\ \beta = 0 \end{cases}$
Tax rate on consumption (τ_c)	* $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = -0.0084 \\ \beta = 0.044 \end{cases}$	* $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	* _(L) 0.0088 * _(M) 0.0280 * _(H) 0.0695
Tax rate on interest income (τ_r)	0.2000	0.2008	0.2002	0.2008	0.2008

2 Aged steady state (2025)

Case	B (Progressive labor income tax)	B-1 (Proportional tax)	B-2 (Progressive consumption tax)	B*	B-2*
Tax rate on labor income (τ_w)	* $\begin{cases} \alpha = 0.00358 \\ \beta = 0.032 \end{cases}$	* $\begin{cases} \alpha = 0.06467 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.06467 \\ \beta = 0 \end{cases}$	* _(L) 0.0206 * _(M) 0.0402 * _(H) 0.0849	* $\begin{cases} \alpha = 0.06467 \\ \beta = 0 \end{cases}$
Tax rate on consumption (τ_c)	* $\begin{cases} \alpha = 0.07955 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.07955 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.03176 \\ \beta = 0.04258 \end{cases}$	* $\begin{cases} \alpha = 0.07955 \\ \beta = 0 \end{cases}$	* _(L) 0.0459 * _(M) 0.0613 * _(H) 0.0954
Tax rate on interest income (τ_r)	0.2000	0.2022	0.2000	0.2022	0.2022

Note: Asterisks (*) before the rate indicate that the variable is exogenous.

3 Parameter values in the two steady states

	Current steady state	Aged steady state
Survival probabilities (p_s)	1995	2025
Growth rate of successive cohorts (n)	0.01462	-0.00446
New entrants in period t (N_t)	1.5	0.844
Labor supply (L_t)	374.6	311.0
Contribution rate (τ_p)	0.1650	0.3397

Table 3.2 *Parameter values used in simulation analysis*

	<i>Parameter values</i>
Parameter for discounting the future	$\delta = -0.0162$
Intertemporal elasticity of substitution	$\gamma = 0.2$
Elasticity of substitution of production	$\sigma = 0.6$
Production weight parameter	$\varepsilon = 0.2$
Production scale parameter	$B = 0.942$
Government expenditure per income class	$g = 0.28279$
Retirement age	$RE = 40$
Starting age for receiving public pension	$ST = 45$
Replacement ratio for public pension	$\theta = 0.634$

Table 3.3 *Income distribution and taxes of households*

<i>Income class</i>	Number of persons (thousand persons)	Total amount of income (billion yen)	Weight on labor endowments	Total amount of taxes (billion yen)	Ratios of the amount of taxes (%)
Low	17,317	30,805	$x^l = 0.465$	776	4.5
Medium	17,317	66,199	$x^m = 1$	2,213	12.9
High	17,317	147,005	$x^h = 2.221$	14,126	82.5
Total	51,950	244,009		17,116	100.0

(Source: *Statistical Year Dissertation of National Taxes 1994*, National Tax Administration Agency, Japan (1996).)

Table 3.4 *Empirical results caused by a progressive labor income tax, a proportional tax, and a progressive consumption tax*

1 Current steady state (1995)

<i>Case</i>	A (Progressive labor income tax)	A-1 (Proportional tax)	A-2 (Progressive consumption tax)	A*	A-2*
Capital-labor ratio (K/L)	2.851	2.781	2.845	2.781	2.781
Interest rate	0.0428	0.0444	0.0430	0.0444	0.0444
Wage rate	0.9821	0.9776	0.9818	0.9776	0.9776
Assets of low income class	151.9	131.5	131.4	152.0	131.5
Assets of high income class	606.0	627.6	649.0	582.7	627.6
Total capital	1,068.1	1,041.8	1,065.9	1,041.8	1,041.8
Utility of low income class	-63.865	-79.109	-67.001	-64.157	-67.416
Utility of high income class	-0.166	-0.153	-0.161	-0.169	-0.164
Social welfare	-67.304	-82.971	-70.538	-67.623	-70.988

2 Aged steady state (2025)

<i>Case</i>	B (Progressive labor income tax)	B-1 (Proportional tax)	B-2 (Progressive consumption tax)	B*	B-2*
Capital-labor ratio (K/L)	2.443	2.381	2.429	2.381	2.381
Interest rate	0.0538	0.0558	0.0543	0.0558	0.0558
Wage rate	0.9533	0.9484	0.9522	0.9484	0.9484
Assets of low income class	118.3	93.5	92.4	119.6	93.5
Assets of high income class	408.8	446.2	461.2	389.0	446.2
Total capital	759.8	740.6	755.2	740.6	740.6
Utility of low income class	-170.980	-230.037	-199.952	-172.839	-202.664
Utility of high income class	-0.489	-0.444	-0.451	-0.510	-0.470
Social welfare	-180.469	-241.267	-210.260	-182.529	-213.209

Table 3.5 *Estimation of the age-profile of earnings ability*

a_0	a_1	a_2
-2.12133 (-8.12860)	0.205776 (14.7803)	-0.00219652 (-13.3314)

$$\begin{cases} S.E. = 0.135 \\ R^2 = 0.968 \end{cases}$$

Table 3.6 *Sensitivity analysis for exogenous changes in labor supply*

Case	Labor supply	(Low) Assets	(Medium) Assets	(High) Assets	Total capital
A	374.6	151.9	310.2	606.0	1,068.1
A-a	363.8	148.7	303.1	590.0	1,041.8
A-b	355.9	146.3	297.8	577.9	1,022.0

Table 3.7 *Estimation of the age-profiles of earnings ability based on educational backgrounds*

<i>Educational backgrounds</i>	a_0	a_1	a_2	
Junior high school graduates	-1.28123 (-4.16363)	0.151411 (9.21858)	-0.00161769 (-8.31822)	$\begin{cases} S.E. = 0.159 \\ R^2 = 0.922 \end{cases}$
High school graduates	-2.60477 (-4.09197)	0.228825 (7.13006)	-0.00241843 (-6.58626)	$\begin{cases} S.E. = 0.262 \\ R^2 = 0.881 \end{cases}$
Junior college graduates, etc.	-3.67363 (-4.39650)	0.276098 (7.06884)	-0.00276330 (-6.52916)	$\begin{cases} S.E. = 0.261 \\ R^2 = 0.896 \end{cases}$
University graduates	-6.04616 (-4.68794)	0.392417 (6.51188)	-0.00364635 (-5.57956)	$\begin{cases} S.E. = 0.373 \\ R^2 = 0.922 \end{cases}$

Table 3.8 *Sensitivity analysis for different rates of the adjustment coefficient for discounting the future, δ*

<i>Case</i>	(Low) Assets	(Medium) Assets	(High) Assets	Total capital
A-c	108.1	299.0	758.8	1,165.8
A-1-c	88.4	269.4	784.3	1,142.1
A-2-c	87.1	273.6	832.9	1,193.5

Table 3.9 *Sensitivity analysis for different intertemporal elasticities of substitution, γ*

<i>Case</i>	(Low) Assets	(Medium) Assets	(High) Assets	Total capital
A-d	83.3	293.2	841.6	1,218.2
A-1-d	63.5	262.5	871.8	1,197.7
A-2-d	64.5	267.5	916.4	1,248.3

Figure 3.1 *Age-profiles of consumption for the high-income class in Cases A-2 (progressive consumption tax) and A-2* (proportional tax)*

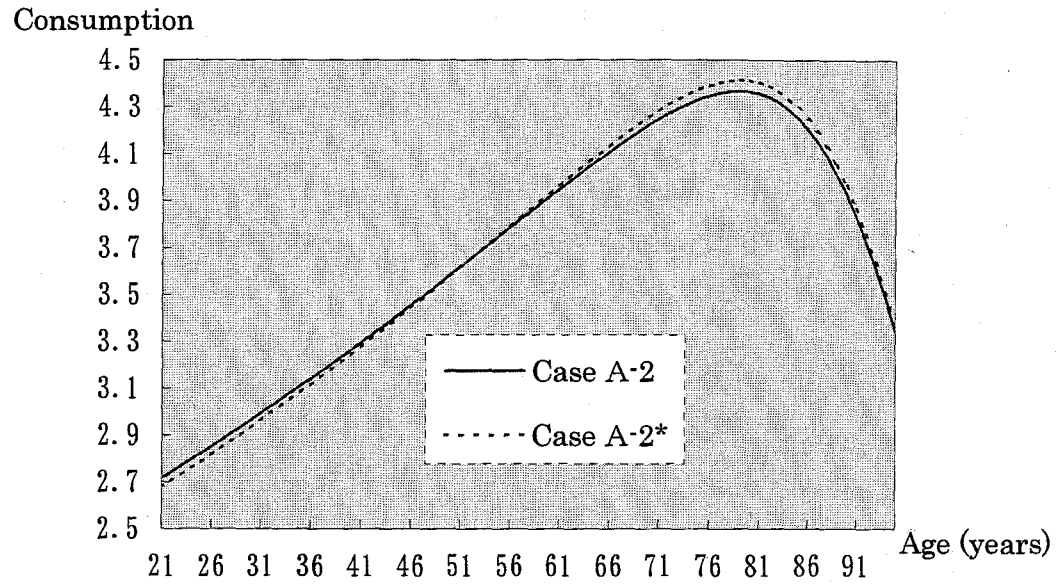


Figure 3.2 *Age-profiles of assets for the high-income class in Cases A (progressive labor income tax) and A* (proportional tax)*

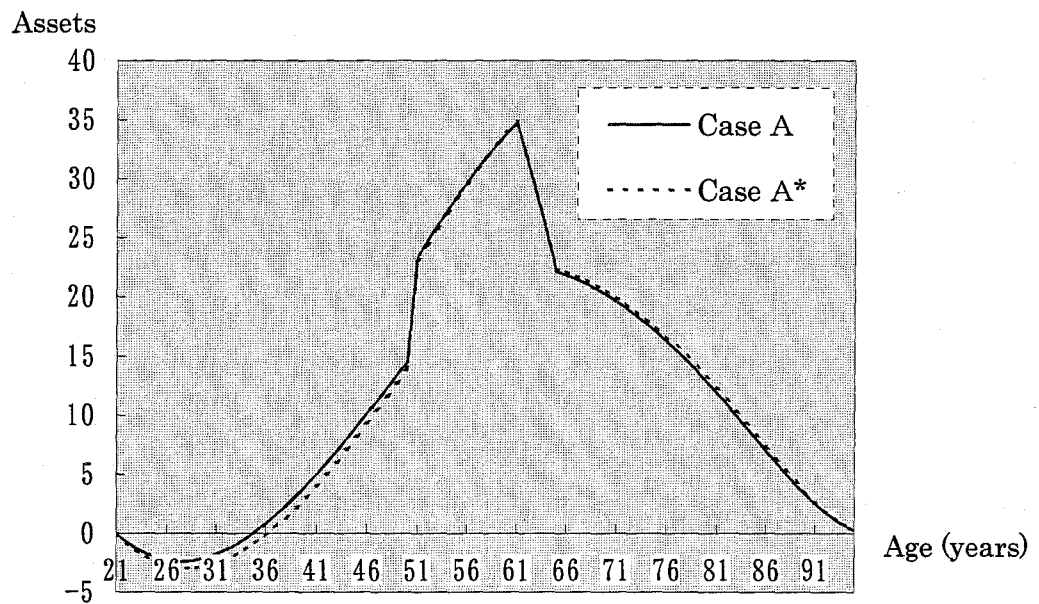


Figure 3.3 *Age-profiles of assets for the high-income class in Cases A-2 (progressive consumption tax) and A-2* (proportional tax)*

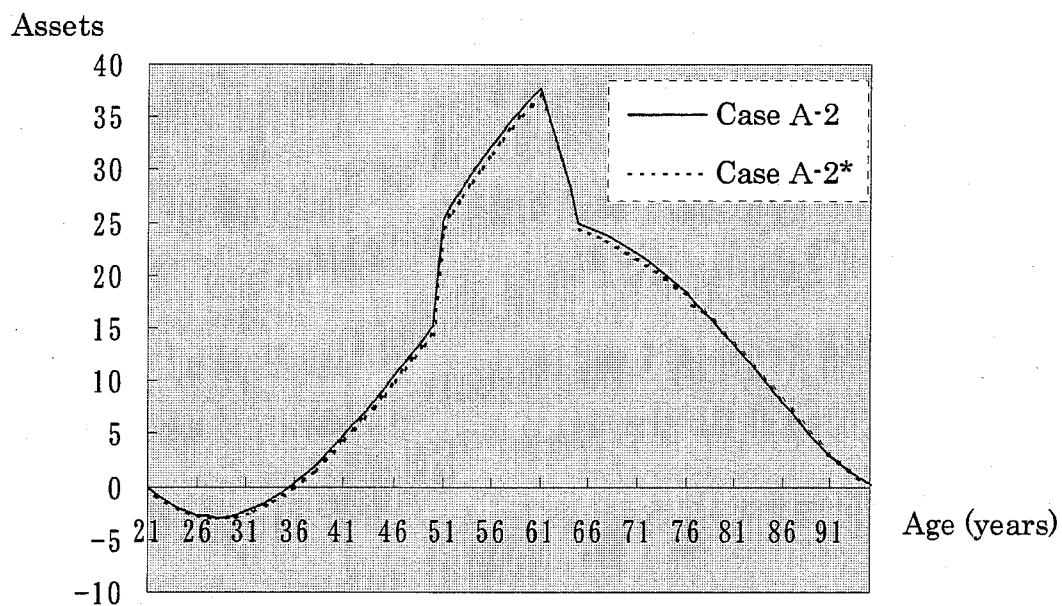
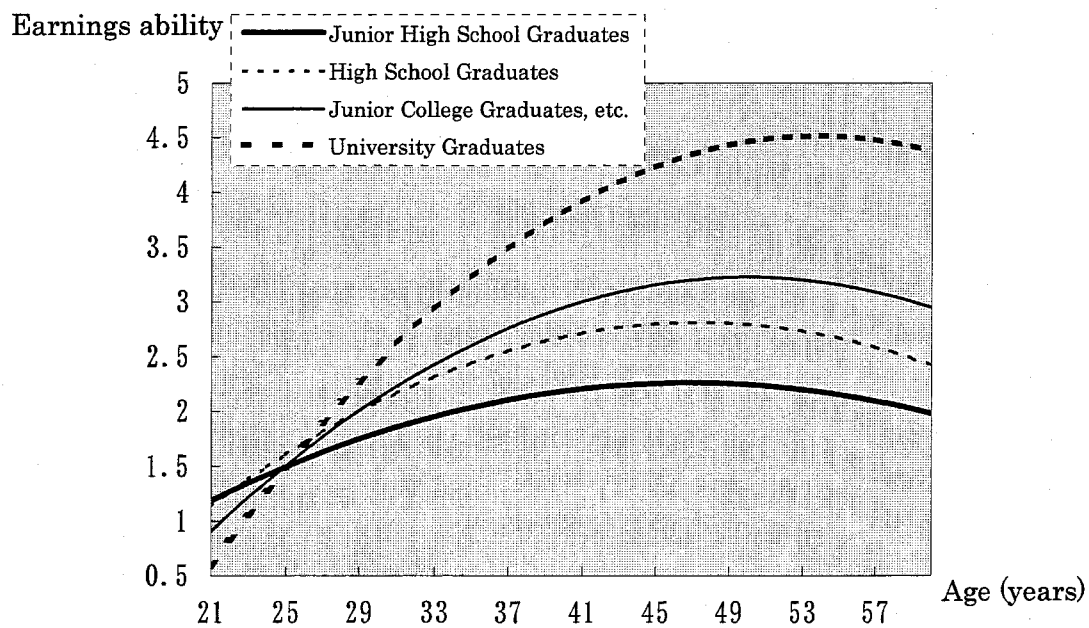


Figure 3.4 *Age-profiles of earnings ability based on educational backgrounds*



4 Simulating progressive expenditure taxation in an aging Japan*

This chapter investigates the effects of tax reform from progressive labor income taxation to progressive expenditure taxation, on capital accumulation and intragenerational income redistribution. The simulation model used in this chapter is fundamentally the same as that in the previous chapter. The role of progressive expenditure taxation is studied in this chapter, and a concrete method for the implementation of this new type of tax regime is also discussed.

4.1 Introduction

The proper choice of tax bases is a significant question, because the choice has important implications for the course of savings and economic growth, the level of economic efficiency, and the distribution of welfare across generations. The current Japanese tax system is based mainly on progressive labor income taxation. However, is the tax schedule really desirable in an aging Japan in terms of efficiency and equity? The effects of progressive expenditure taxation on social welfare as an alternative tax base will be evaluated in this chapter.

* An earlier version of this chapter was presented at the *2000 Annual Meeting of the Japanese Economic Association* held at Osaka Prefecture University. I am grateful for insightful comments and suggestions by Professors Toshiaki Tachibanaki, Yukinobu Kitamura, Yasushi Iwamoto, Masahiro Hidaka, and from the seminar participants. I also acknowledge the financial support from the Ministry of Education, Culture, Sports, Science and Technology in Japan (the Grant-in-Aid for Encouragement of Young Scientists No.13730064).

The purpose of this chapter is to clarify guidelines for structural tax reforms in an aging Japan, by comparing progressive labor income taxation and progressive expenditure taxation in terms of efficiency and equity. The chapter investigates the quantitative effects of tax reform from progressive labor income taxation to progressive expenditure taxation, on capital accumulation as well as intragenerational income redistribution. It examines the macroeconomic and welfare effects of alternative tax schemes in each of two steady states, one with the current Japanese age structure and the other with the age structure projected for 2025.

A life-cycle general equilibrium simulation model is suitable as a basic theoretical framework to examine rigorously the impact of demographic changes on various social and economic variables. Nearly all studies based on the model analyzed the effects of an aging population on production and consumption, and thus on economic growth. When dealing with tax reforms, however, it is vital to evaluate not only efficiency but also equity. We employ an extended life-cycle general equilibrium model of overlapping generations with the difference of earnings ability. This enables us to investigate equity issues in addition to efficiency issues. Thus, this chapter should present comprehensive and useful guidelines for tax reforms.

The main theme in this chapter is to study the role of progressive expenditure taxation. Few studies have dealt with this new type of tax regime to evaluate the effects of structural tax reforms. Since there are only a few studies on progressive expenditure taxation, our analysis has some merit as a pioneering work. Progressive expenditure taxation will be evaluated for its efficiency and equity, in comparison with progressive labor income taxation.

This chapter is organized as follows: Section 4.2 describes the basic model employed in simulation analysis. Section 4.3 explains the method of simulation analysis and the assumptions adopted. Section 4.4 evaluates the simulation findings and discusses policy implications. Section 4.5 summarizes and concludes the chapter.

4.2 Theoretical framework

We calibrate the simulation of the Japanese economy by employing population data estimated by the Institute of Population Problems of the Ministry of Health and Welfare in 1997. The model has 75 different overlapping generations. Three types of agents are considered: households, firms, and the government. Since the basic model in this chapter is the same as that in Chapter 3, see 3.2 *Theoretical framework* for detailed explanation. The basic structure of households is as follows.

4.2.1 Household behavior

Let $q_{j+1|j}$ be the conditional probability that a household of age $j + 20$ lives to $j + 21$. Then the probability of a household of age 21 surviving until $s + 20$ can be expressed by

$$p_s = \prod_{j=1}^{s-1} q_{j+1|j}. \quad (4.1)$$

The probability $q_{j+1|j}$ is calculated from data estimated in 1997 by the Institute of Population Problems of the Ministry of Health and Welfare. The utility function of a representative household, whose form is assumed to be time-separable, is

$$U^i = \frac{1}{1 - \frac{1}{\gamma}} \sum_{s=1}^{75} p_s (1 + \delta)^{-(s-1)} \{C_s^i\}^{1 - \frac{1}{\gamma}}, \quad (4.2)$$

where C_s^i represents consumption (or expenditure) at age $s + 20$, δ the adjustment coefficient for discounting the future, and γ the intertemporal elasticity of substitution on consumption. The superscript $i (= l, m, h)$ stands respectively for low, medium, and high-income class.

The flow budget constraint equation for each household at age $s + 20$ is

$$A_{s+1}^i = \{1 + r(1 - \tau_r)\} A_s^i + \{1 - \tau_w(w x^i e_s) - \tau_p\} w x^i e_s + b_s^i + a_s^i - \{1 + \tau_c(C_s^i)\} C_s^i, \quad (4.3)$$

where A_s^i represents the amount of assets held by the household at the beginning of age $s + 20$, r the interest rate, w the wage rate per efficiency unit of labor, and e_s the age-profile of earnings ability for the household that belongs to the medium income

class.¹ b_s^i is the amount of public pension benefit, and a_s^i is the amount of bequest to be inherited at age $s + 20$. $\tau_w(wx^i e_s)$ is the tax rate on labor income, $\tau_c(C_s^i)$ that on consumption, τ_r that on interest income, and τ_p is the contribution rate to a public pension scheme. x^i is the weight coefficient corresponding to the different levels of labor endowments among the three income classes. The medium income class is used as a yardstick, and thus $x^m = 1$. x^l and x^h reflect the realistic difference of earnings ability across the three income classes.

Variables related to the public pension program in a pay-as-you-go system are represented by

$$\begin{cases} b_s^i = \theta H^i & (s \geq ST) \\ b_s^i = 0 & (s < ST) \end{cases}, \quad (4.4)$$

where the age at which each household starts to receive public pension benefits is

$ST + 20$, the average annual remuneration is $H^i \left(= \frac{1}{RE} \sum_{s=1}^{RE} wx^i e_s \right)$, and the

replacement ratio is θ .

When BQ_t^i is the sum of bequests inherited by 50-year-old households at period t , a_{30}^i is defined by

$$a_{30}^i = \frac{BQ_t^i}{N_t p_{30} (1+n)^{-29}}, \quad (4.5)$$

where

$$BQ_t^i = N_t \sum_{s=1}^{75} (p_s - p_{s+1}) (1+n)^{-(s-1)} A_{s+1}^i,$$

N_t is the number of new households entering the economy as decision-making units at period t , and n is the common growth rate of successive cohorts.

From the utility maximization problem, the equation expressing evolution of consumption over time for each household is characterized by

$$C_{s+1}^i = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \left(\frac{1+\tau_c(C_s^i)}{1+\tau_c(C_{s+1}^i)} \right) \right]^{\gamma} C_s^i. \quad (4.6)$$

If initial consumption level, C_1^i , is specified, optimal consumption behavior of all ages can be calculated from equation (4.6). The amount of assets held by each household at

each age can be obtained from equation (4.3). The expected lifetime utility of each household is derived from equation (4.2).

The social welfare function, which takes account of the difference in earnings ability and thus resulting in the different levels of consumption, is given by

$$SW = q^l U^l + q^m U^m + q^h U^h, \quad (4.7)$$

where q^i ($i=l, m, h$) is the weight coefficient given to each income class. This function is derived from a summation of the expected lifetime utilities at age 21 for the three income classes.

As for the basic structure of firms, a single production sector is assumed to behave competitively using capital and labor, subject to a constant-returns-to-scale production function. See Appendix 4.A for the basic structures of firms and the government, and market equilibrium conditions.

4.3 Simulation analysis

4.3.1 Simulations cases

In order to capture the altered demographics in Japan from the current time of 2000 to 2025, we consider the two demographic regimes, namely, current and aged. Alternative tax bases are contrasted in the economy with the age structure projected for 2025, through comparing steady states. Case A is the benchmark of the 2000 current steady state. In Case A, the tax system on labor income has a realistic progressiveness (see 4.3.2 *Specification of parameters* for the assignment of the parameter values that determine tax progressivity, α and β), and the tax rates on consumption and interest income are 5 and 20 percent, respectively.

Case B is the benchmark of the aged steady state projected for 2025, in which tax rates on the three tax regimes are the entirely same as in Case A. If in Case B, a progressive labor income tax covers the total revenue, this case is then labeled Case B-1. If in Case B-1, a proportional labor income tax replaces a progressive one, this case is then labeled Case B-1*. Similarly, if in Case B, a progressive expenditure tax

covers the overall revenue, this case is then labeled Case B-2. If in Case B-2, a proportional expenditure tax replaces a progressive one, this case is then labeled Case B-2*.

The 'Case-B' simulations consider an aged society (2025): the difference is in the population structure and the level of labor endowments. Different survival probabilities (p_s) and different growth rates of successive cohorts (n) create different age structures of the population between the two demographic regimes (see Table 4.2 for the parameter values that characterize the two steady states).

In an aging society, Japan faces a decline in the proportion of working population, with a subsequent decrease in aggregate output (Y_t); hence, a rise in the ratio of the total tax revenue (T_t) to aggregate output (Y_t), substantially increases the tax burden in an aged state. A rise in labor endowments covers this extra tax burden caused by the transition from the current to the aged states. To avoid a rise in tax rates in an aged state, we introduce the technological progress (ϕ) that increases the labor endowments. It should be noted that in the 'Case-B' simulations, $(1 + \phi)e_s$ replaces e_s . The technological progress (ϕ) is chosen so that the benchmark case B projected for 2025 can have the same tax rates on the three tax bases as in the 2000 benchmark case A.

In order to ascertain the clear effects of tax reforms, we assume tax revenue neutrality for all the simulation cases. New entrants in period t (N_t) are adjusted so that the number of households is the same between the current and aged cases. Thus, the size of population is the same for all cases. The government expenditure per household is exogenously given and constant for all cases. Therefore, the overall tax revenue (T_t) is exogenous and the same across all simulation cases.

4.3.2 Specification of parameters

Table 4.3 presents the parameter values used in the simulation. This chapter investigates the implications of alternative tax policies for an aging Japanese economy.

Hence, we choose parameter values realistic for the economy. In the benchmark case A, the economic variables, such as the ratio of capital to income (K/Y) or that of capital to labor (K/L), are close to actual values of 2000.

We introduce the technological progress (ϕ) in a transition from the current time to 2025. By a 10.12 percent technological progress for 25 years (i.e., 0.39 percent per annum), the same tax rates on the three taxes can generate the same total revenue between the current and aged benchmark cases. For the public pension system, the replacement ratio of pension payments (θ) in Case A is chosen so that the contribution rate (τ_p) equals the actual value of 17.35 percent in employees' pension plans (*Kosei Nenkin*) in 2000.

1 The "Population Projections for Japan: 1996-2100"

First, survival probabilities (p_s) are calculated from the *Population Projections for Japan 1996-2100*, a 1997 publication by the Institute of Population Problems of the Ministry of Health and Welfare. Our model makes no sex distinction, and so this study uses the male-female average values for 2000 and 2025. Following the estimation using the above data, the percentages of aged population (65 or above) to the total population (21 or above) in 2000 and 2025 are 22.04 and 33.86 percent, respectively. The common growth rates of successive cohorts (n) are chosen so that the percentages in the simulation are the same as these estimated values.

2 The "Statistical Year Dissertation of National Taxes 1997"

Next, the method of assigning the weight given to labor endowments for each income class, namely, low, medium, and high, is explained. We use data that includes all ranges of individual income taxes, by adding two sources: data for income tax collected at the tax office; and data for self-assessed income tax. The data is based on the *Statistical Year Dissertation of National Taxes (Kokuzeicho Tokei-Nenposho) 1997*, National Tax Administration Agency, Japan (1999). Table 4.4 suggests that the weight

coefficient on each income class, i.e., q^l , q^m , and q^h , is estimated based on each number of people. Similarly, each weight coefficient on earnings ability, namely, x^l , x^m , and x^h , is estimated based on each amount of income.

Finally, the method of assigning the parameter values on the degree of tax progressivity, namely, α and β , is described. The parameters on labor income in the benchmark case A are chosen so that for the three income classes, the ratios of tax revenue from labor income are the same as the realistic ratios indicated by Table 4.4. The overall average tax rate on labor income is set to 5.79 percent that is led by the above data.

We assigned the parameter values on labor income in Case B-1 (progressive labor income taxation) and on expenditure in Case B-2 (progressive expenditure taxation). It is difficult to get a strictly identical degree of tax progressivity across the three simulation cases with the different tax structure, namely, B, B-1, and B-2. Hence, we have decided to assign the parameter values so that the total tax revenue (i.e., the sum of the three kinds of tax regimes) for each income class is the same across the three cases (see Table 4.5 for the assignment of parameter values on tax progressivity).

4.4 Simulation results

We compare progressive labor income taxation and progressive expenditure taxation in terms of efficiency and equity. The 'Case-B' simulations in the aged steady state are focused mainly on and discussed below, because we are interested in how tax reforms will affect the economy of an aging Japan in the future (see Table 4.5 for the simulation results in the current and aged states).

4.4.1 Findings and their interpretation

First of all, different tax regimes are evaluated using the social welfare function that takes into account of efficiency and equity in a comprehensive way. Among all 'Case-B' simulations, progressive expenditure taxation (Case B-2) has the highest level of social

welfare (−8.53). Then progressive labor income taxation (Case B-1) comes with −13.06, and finally the current tax system (Case B) with −14.72. The main reason is that progressive expenditure taxation stimulates more capital formation than progressive labor income taxation.

Next, we focus on the difference in the capital-labor ratio (K/L) between the current and aged state cases. In the current benchmark case A of 2000, the ratio is equal to 2.98. However, in the aged benchmark case B projected for 2025 it decreases to 2.88. This is because in an aging society, there are many generations who dissave their assets based on the life-cycle motive. The tax policies that enhance capital accumulation are required in an aging society in terms of efficiency. Therefore, we recommend progressive expenditure taxation as the most desirable tax regime, especially in an aging Japan where the capital stock would decline. Below, progressive labor income taxation and progressive expenditure taxation are first compared in terms of efficiency, and then they are compared in terms of equity.

1 Comparison of the two tax systems in terms of efficiency

First, both of the tax systems are examined as regards efficiency. The simulation results suggest that the capital stock is larger under an expenditure tax than under a labor income tax, whether it is progressive or proportional taxation. Under progressive expenditure taxation (Case B-2) the capital-labor ratio (K/L) is 3.70, while it is 2.47 under progressive labor income taxation (Case B-1). Thus, progressive expenditure taxation brings forth much more capital accumulation than progressive labor income taxation. Hence, progressive expenditure taxation is preferable to progressive labor income taxation in terms of efficiency.

2 Comparison of the two tax systems in terms of social welfare

Next, the two tax regimes are evaluated as regards social welfare. The level of social welfare is much higher under progressive expenditure taxation (Case B-2) than under

progressive labor income taxation (Case B-1): the corresponding value is respectively -8.53 and -13.06 . It should be noted that the social welfare function represented by equation (4.7) depends on the aspects of both efficiency and equity. As for efficiency, an expenditure tax stimulates more capital formation than a labor income tax. Social welfare is -9.43 under proportional expenditure taxation (Case B-2*) and it is -15.77 under proportional labor income taxation (Case B-1*). As for equity, progressive taxation reduces the dispersion of income distribution. Hence, the move from proportionality to progressivity improves social welfare, whether the tax base is labor income or expenditure.

4.4.2 Effects of the two tax systems on capital accumulation

1 "Capital increasing effect" of progressive taxation

Under the taxation on labor income or expenditure, the transfer from proportionality to progressivity increases the capital-labor ratio (K/L). With the switching from Case B-1* to B-1, the ratio increases from 2.36 to 2.47. Similarly, with the transferring from Case B-2* to B-2, it increases from 3.61 to 3.70. This is because our model assumes an inelastic labor supply: tax progressivity has no negative impacts on labor supply. If the tax-induced disincentive effect on labor supply were taken into account, the moving to progressive taxation would not always enhance capital accumulation.

Progressive taxation stimulates capital formation through a change in the timing of taxation. This is verified if progressive labor income taxation is implemented under a pay scale based on seniority, or if progressive expenditure taxation is incorporated under the age-profile of consumption with an upward slope. This "capital increasing effect" is caused by changing the timing of taxation to occur later in the life cycle under tax progressivity. If labor income or consumption grows over the life cycle, households accumulate more assets to maximize their lifetime utility (see Chapter 3 for further details of the "capital increasing effect").

Figures 4.1 and 4.2 present the age-profiles of savings and assets, respectively, for

Cases B-1 and B-2. Under progressive expenditure taxation (Case B-2), an increase in the tax burden at the old period requires individuals to have a larger amount of savings, resulting in more assets.

2 Effects of progressive expenditure taxation on capital accumulation

Progressive expenditure taxation brings about more capital formation than progressive labor income taxation. A high level of capital accumulation under progressive expenditure taxation (Case B-2) is dependent mainly on the large amount of the assets of the high-income class. In Case B-2 the assets of the high-income class account for 65.5 percent of the capital stock, while those in Case B-1 (progressive labor income taxation) make up only 62.2 percent.

With the move from Case B-2* to B-2 under an expenditure tax, the assets of the high-income class rise by 3.5 percent. With the transferring from Case B-1* to B-1 under a labor income tax, they increase by only 0.4 percent. This observation suggests that under an expenditure tax, the assets of the high-income class substantially increase with the transition from proportionality to progressivity. Under progressive expenditure taxation, the “capital increasing effect” strongly works especially for the high-income class.

This is because by a property of progressivity, the changes in tax rates for the high-income class are more striking than those for the low or medium income class during the life cycle. In Case B-2, the change in tax rates on expenditure for the high-income class ranges from 13.0 percent to 15.3 percent in an entire lifetime. That for the low-income class ranges only from 10.4 percent to 10.8 percent. Therefore, the high-income class has a greater “capital increasing effect” of progressive taxation.

4.4.3 Effects of the two tax systems on individual behavior

If labor income or consumption grows over the life cycle, both of the progressive tax regimes change the timing of taxation to occur later in the lifetime. Progressive labor

income taxation changes the time path of disposable labor income, while progressive expenditure taxation distorts the intertemporal consumption choice. The distortions of progressive labor income taxation are first investigated, and then those of progressive expenditure taxation are evaluated. Finally, our simulation results are compared with those obtained by Auerbach and Kotlikoff (1987) with an *elastic* labor supply.

1 Effects of progressive labor income taxation on individual behavior

First, the effects of progressive labor income taxation on individual behavior are discussed. Since our model assumes an inelastic labor supply, progressive labor income taxation has no negative impacts on labor supply. Hence, the effects of progressive labor income taxation are restrictive in our analysis. Given the age-profile of labor income with an upward slope, progressive labor income taxation changes the time path of after-tax labor income, namely labor income minus the tax and contributions to a public pension program.

Figure 4.3 presents that the age-profile of disposable labor income is gentler and lower under progressive labor income taxation (Case B-1) than under progressive expenditure taxation (Case B-2). Figure 4.4 suggests that the profile is gentler and lower under tax progressivity (Case B-1) than under proportionality (Case B-1*). Under the assumption of an inelastic labor supply, only the income effect exists when the time path of disposable income changes.

2 Distortions of progressive expenditure taxation on individual behavior

Next, how progressive expenditure taxation distorts individual consumption-savings behavior is examined.² Under progressive expenditure taxation, households make the level of consumption (or expenditure) in each age gentler over the life cycle. This is because households that maximize their lifetime utility tend to avoid having high tax rates. Figure 4.5 presents that the age-profile of consumption is gentler and lower under progressive expenditure taxation (Case B-2) than under progressive labor

income taxation (Case B-1). Figure 4.6 suggests that the profile is gentler and lower under tax progressivity (Case B-2) than under proportionality (Case B-2*).

When an expenditure (or consumption) tax is progressive and rates rise with age as considered in this chapter, it distorts the intertemporal consumption choice, as represented by equation (4.6). Rising marginal consumption tax rates, like an interest income tax, raise the price of future consumption relative to current consumption. Through this channel, progressive expenditure taxation distorts the household's intertemporal consumption decisions. Hence, we might expect this distortion to lead to a substantial reduction in savings and thus in the long-run capital stock. However, our simulation results suggest that progressive expenditure taxation brings about much more capital formation than progressive labor income taxation.

3 Comparison with the simulation results in an earlier study

Finally, we compare our simulation results and the results obtained by Auerbach and Kotlikoff (1987) that assume an *elastic* labor supply. Especially in the case of progressive taxation, households' behavior is distorted less under the taxation on expenditure (or consumption) than under the taxation on labor income. This is supported with two observations:

One is that with the move from proportionality to progressivity, the capital stock declines less under a consumption tax than under a labor income tax, which continues to leave the intertemporal consumption decision undistorted. The other is that with the transferring from proportionality to progressivity, labor supply decreases less under a consumption tax than under a labor income tax. Hence, that study suggests that households' behavior is distorted less under an expenditure (or consumption) tax than under a labor income tax, especially in the case of progressive taxation.

Since we assume an *inelastic* labor supply, in this respect, progressive labor income taxation in our model has an advantage over progressive expenditure taxation. Our simulation results, nevertheless, indicates that progressive expenditure taxation

is superior to progressive labor income taxation in terms of efficiency. This fact should be stressed when we recommend progressive expenditure taxation as the most desirable tax regime in an aging Japan.³

We take account of the effects of demographics, by comparing the two steady states, namely, current and aged. Thus, our analysis lacks consideration of a transitional path. A change from a labor income tax to a consumption tax creates income transfers among generations during the transition. At the onset of a policy reform, the elderly who had already paid their labor income tax will have to pay an additional consumption tax. Since this generation would suffer from a double burden, the transition to a consumption-based tax is not Pareto improving. As this fact is well known, the conclusion that recommends a consumption-based tax will be required to provide further justification, that is, to suggest measures to avoid a double burden during the transition.

4.5 Conclusions

This chapter has examined the quantitative effects of tax reform from progressive labor income taxation to progressive expenditure taxation on efficiency and equity in Japan, a society with an aging population. To analyze this situation, we have adopted a comparative steady state simulation approach for an extended life-cycle general equilibrium model of overlapping generations with the difference of lifetime earnings ability. The simulation results suggest some advantages of a new tax system of progressive expenditure taxation. Three major conclusions have been drawn from the simulation.

First, the capital stock would decline as population aging, because there are many generations who dissave their assets based on the life-cycle motive. Progressive expenditure taxation stimulates more capital accumulation than progressive labor income taxation. The assets of the high-income class play a significant role for capital

formation under progressive expenditure taxation. In terms of efficiency, progressive expenditure taxation is superior to progressive labor income taxation.

Second, progressive expenditure taxation distorts the household's intertemporal consumption decision. Given the age-profile of consumption with an upward slope, the taxation distorts individual behavior through raising the price of future consumption relative to current consumption. Our simulation result, nevertheless, suggests that households' behavior is distorted less under progressive expenditure taxation than under progressive labor income taxation. It should be noted that this result has been obtained on the assumption of an *inelastic* labor supply. The findings in Auerbach and Kotlikoff (1987) with an *elastic* labor supply enable us to undertake the estimation that follows: if labor supply were assumed to be *elastic* in our model, progressive expenditure taxation would bring forth even more favorable results than progressive labor income taxation.

Third, progressive expenditure taxation attains the highest level of social welfare, which takes into account of efficiency and equity in a comprehensive way. Therefore, this taxation is preferable to other tax systems such as progressive labor income taxation or the current Japanese system. We recommend progressive expenditure taxation as one of the most desirable tax regimes in an aging Japan.

4.5.1 How can a progressive expenditure tax be implemented?

Finally, we present the concrete measures of carrying out progressive expenditure taxation. Conceptually, it is easy to introduce progressive expenditure taxation. Feasibility of implementing progressive expenditure taxation, however, contains a serious problem in the real world: that is to measure and grasp the figures of each individual's expenditure. For its implementation, it is necessary to grasp the total amount of annual expenditure for each household. This implies that a tax authority has to grasp the whole picture of consumption activities of each individual in detail. How can we measure a tax base that is defined by expenditure? We propose that it is

feasible to measure it in the method that follows.

There is an equation that income is equal to consumption (or expenditure) plus savings. If the amount of both income and savings is available for each individual, the balance is equal to the amount of expenditure. The income figure is efficiently obtained using the current Japanese system of withholding taxes at the income source. The savings figure can be obtained through the self-assessment system. It should be emphasized that the self-assessment of savings is the exact opposite to that of income in terms of an individual incentive. The more an individual declares savings, the lower tax rates on expenditure the individual has. This is entirely contrastive to the case of the self-assessment of income.

The savings figure can be consolidated using an electronic financial system. All financial institutions are requested to report the total amount of financial assets held by each individual with an individual tax number (or a social security number) to a tax office. Thus, the tax office is able to grasp the overall wealth of each individual. Of course, this feasibility depends solely on the development of a computer-based financial system. The introduction of progressive expenditure taxation is our recommendation in the long-term perspective.

Appendix 4.A

Section 4.2 describes the basic structure of households. This appendix presents those of firms and the government, and market equilibrium conditions.

Firm behavior

The production function is assumed to be of the constant elasticity of substitution form:

$$Y_t = B \left[\varepsilon K_t^{1-\frac{1}{\sigma}} + (1-\varepsilon) L_t^{1-\frac{1}{\sigma}} \right]^{\frac{1}{1-\frac{1}{\sigma}}}, \quad (4.8)$$

where Y_t represents the total output, K_t the total capital, L_t the total labor supply

measured by the efficiency units, B a scaling constant, ε a parameter measuring the intensity of use of capital in production, and σ the elasticity of substitution between K_t and L_t . Using the property subject to a constant-returns-to-scale production function, we can obtain the following equation:

$$Y_t = rK_t + wL_t. \quad (4.9)$$

Government behavior

The budget constraint of the narrower government sector at time t is given by

$$G_t = T_t, \quad (4.10)$$

where G_t is government spending on goods and services in year t , and T_t is the total tax revenue from labor income, interest income, and consumption. The public pension program is assumed to be a simple pay-as-you-go system. The budget constraint of pension sector at time t is given by

$$R_t = B_t, \quad (4.11)$$

where R_t is the total contribution to the pension scheme, and B_t is the total pension benefits to generations of age $ST + 20$ and above.

G_t , T_t , R_t , and B_t are defined respectively by

$$G_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} g, \quad (4.12)$$

$$T_t = LX_t + \tau_r rAS_t + CX_t, \quad (4.13)$$

$$R_t = \tau_p wL_t, \quad (4.14)$$

$$B_t = N_t \sum_{s=ST}^{75} p_s (1+n)^{-(s-1)} \{q^l b_s^l + q^m b_s^m + q^h b_s^h\}, \quad (4.15)$$

where g is annual government expenditure for each cohort. LX_t and CX_t are tax revenues from labor income and consumption (or expenditure), respectively. Since we consider the existing proportion of each income class, the revenues are derived from a weighted summation of the three income classes:

$$LX_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} \left[q^l \left\{ \alpha w x^l e_s + \frac{1}{2} \beta (w x^l e_s)^2 \right\} + q^m \left\{ \alpha w x^m e_s + \frac{1}{2} \beta (w x^m e_s)^2 \right\} + q^h \left\{ \alpha w x^h e_s + \frac{1}{2} \beta (w x^h e_s)^2 \right\} \right], \quad (4.16)$$

$$CX_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \left[q^l \left\{ \alpha C_s^l + \frac{1}{2} \beta (C_s^l)^2 \right\} + q^m \left\{ \alpha C_s^m + \frac{1}{2} \beta (C_s^m)^2 \right\} + q^h \left\{ \alpha C_s^h + \frac{1}{2} \beta (C_s^h)^2 \right\} \right]. \quad (4.17)$$

Similarly, the total public pension benefits, B_t , aggregate assets supplied by households, AS_t , and aggregate consumption, AC_t , are obtained by a weighted summation of the three income groups:

$$AS_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \{ q^l A_s^l + q^m A_s^m + q^h A_s^h \}, \quad (4.18)$$

$$AC_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \{ q^l C_s^l + q^m C_s^m + q^h C_s^h \}. \quad (4.19)$$

Market equilibrium

Finally, equilibrium conditions for the capital, labor, and goods markets are described.

1 Equilibrium condition for the capital market

$$AS_t = K_t. \quad (4.20)$$

2 Equilibrium condition for the labor market

$$L_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} \{ q^l x^l + q^m x^m + q^h x^h \} e_s. \quad (4.21)$$

3 Equilibrium condition for the goods market

$$Y_t = AC_t + (K_{t+1} - K_t) + G_t. \quad (4.22)$$

An iterative program is performed to obtain the equilibrium values of the above equations (see Appendix 3.B for the computation process).

Table 4.1 *Estimation of the age-profile of earnings ability*

a_0	a_1	a_2	a_3	a_4
-0.46367 (-1.2088)	0.09931 (3.6855)	-0.001265 (-4.9937)	0.11744 (3.3820)	-0.001067 (-1.1799)

$$\begin{cases} S.E. = 0.0528 \\ R^2 = 0.9976 \end{cases}$$

Table 4.2 *Parameter values that characterize the two steady states*

	<i>Current steady state</i>	<i>Aged steady state</i>
Survival probabilities (p_s)	2000	2025
Growth rate of successive cohorts (n)	0.01056	-0.00515
New entrants in period t (N_t)	1.5	0.9154
Rate of technological progress (ϕ)	0	0.1012
Labor supply (L_t)	199.62	190.12
Contribution rate (τ_p)	0.1735	0.3082

Table 4.3 *Parameter values used in simulation analysis*

	Parameter values
Adjustment coefficient for discounting the future	$\delta = -0.022$
Intertemporal elasticity of substitution	$\gamma = 0.2$
Elasticity of substitution in production	$\sigma = 0.6$
Weight parameter in production	$\varepsilon = 0.2$
Scale parameter in production	$B = 0.942$
Government expenditure for each cohort	$g = 0.38502$
Retirement age	$RE = 40$
Starting age for receiving public pension benefit	$ST = 45$
Replacement ratio for public pension	$\theta = 0.55119$

Table 4.4 *Income distribution and taxes of households*

<i>Income class</i>	Number of persons (thousand persons)	Proportion of the income class	Total amount of income (billion yen)	Weight on labor efficiency	Total amount of taxes (billion yen)	Proportion of the amount of taxes (%)
Low	18,258	$q^l = 0.3410$	32,972	$x^l = 0.5120$	972	6.49
Medium	16,337	$q^m = 0.3052$	64,403	$x^m = 1$	2,473	16.52
High	18,940	$q^h = 0.3538$	161,125	$x^h = 2.5018$	11,520	76.98
Total	53,535	1	258,500		14,964	100.00

(Source: *Statistical Year Dissertation of National Taxes 1997*, National Tax Administration Agency, Japan (1999).)

Table 4.5 *Empirical results caused by progressive labor income taxation and progressive expenditure taxation*

<i>Case</i>	A (Current state benchmark)	B (Aged state benchmark)	B-1 (Progressive labor income tax)	B-1* (Proportional labor income tax)	B-2 (Progressive expenditure tax)	B-2* (Proportional expenditure tax)
Tax rate on labor income ($\tau_w(w x^i e_s)$)	* $\begin{cases} \alpha = 0.0222 \\ \beta = 0.0115 \end{cases}$	$\begin{cases} \alpha = 0.0222 \\ \beta = 0.0115 \end{cases}$	* $\begin{cases} \alpha = 0.1076 \\ \beta = 0.0102 \end{cases}$	* $\begin{cases} \alpha = 0.1426 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$
Tax rate on consumption ($\tau_c(C_s^i)$)	* $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.0965 \\ \beta = 0.0175 \end{cases}$	* $\begin{cases} \alpha = 0.1330 \\ \beta = 0 \end{cases}$
Tax rate on interest income (τ_i)	0.20000	0.20000	0.00000	0.00000	0.00000	0.00000
Capital-labor ratio (K/L)	2.980	2.878	2.472	2.359	3.695	3.608
Interest rate (r)	0.0401	0.0422	0.0529	0.0566	0.0291	0.0301
Wage rate (w)	0.9901	0.9838	0.9555	0.9465	1.0266	1.0227
(Low) Assets (AS_t^l)	80.92	70.51	66.01	57.38	87.61	87.75
(High) Assets (AS_t^h)	375.54	307.35	292.13	290.87	460.28	444.82
Total capital (K_t)	594.95	496.86	469.90	448.54	702.44	685.94
(Low) Utility (U^l)	-20.006	-40.460	-35.880	-43.498	-23.487	-25.996
(High) Utility (U^h)	-0.0415	-0.0875	-0.0790	-0.0763	-0.0463	-0.0456
Social Welfare (SW)	-7.275	-14.722	-13.059	-15.774	-8.534	-9.427

Note: Asterisks (*) before the rate indicate that the variable is exogenous.

Figure 4.1 *Age-profile of savings for the high-income class in Cases B-1 and B-2*

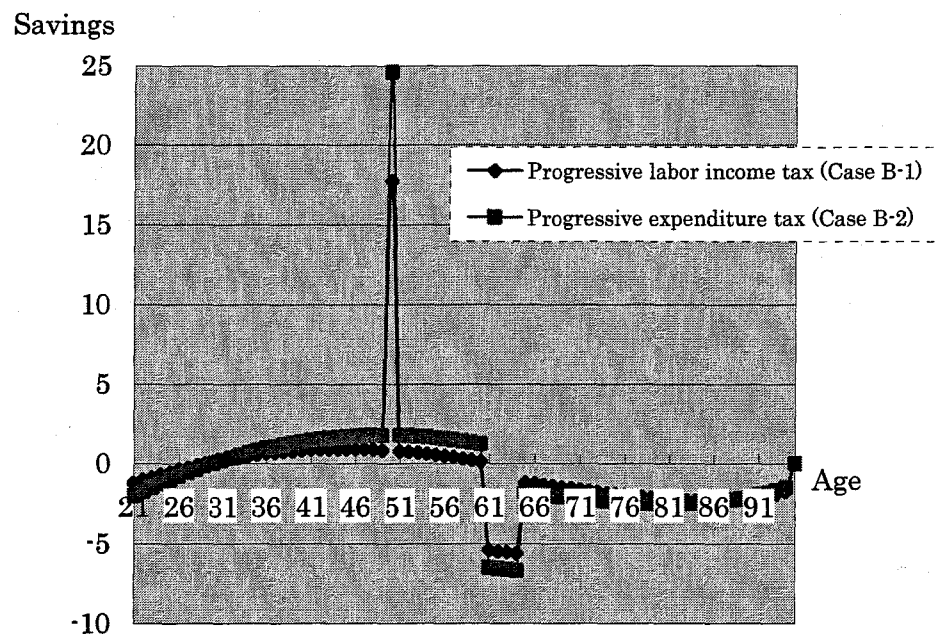


Figure 4.2 *Age-profile of assets for the high-income class in Cases B-1 and B-2*

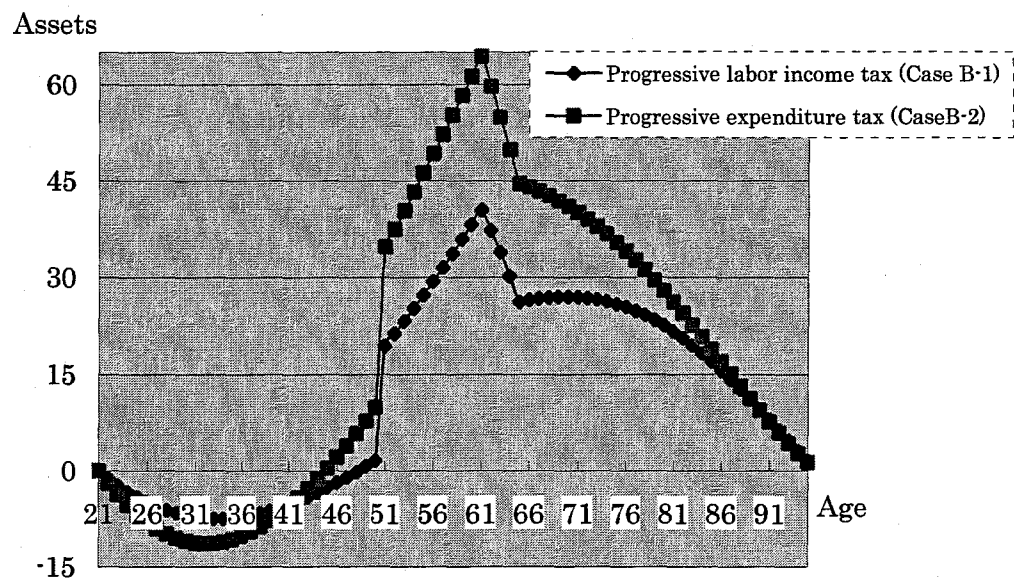


Figure 4.3 *Age-profile of disposable labor income for the high-income class in Cases B-1 and B-2*

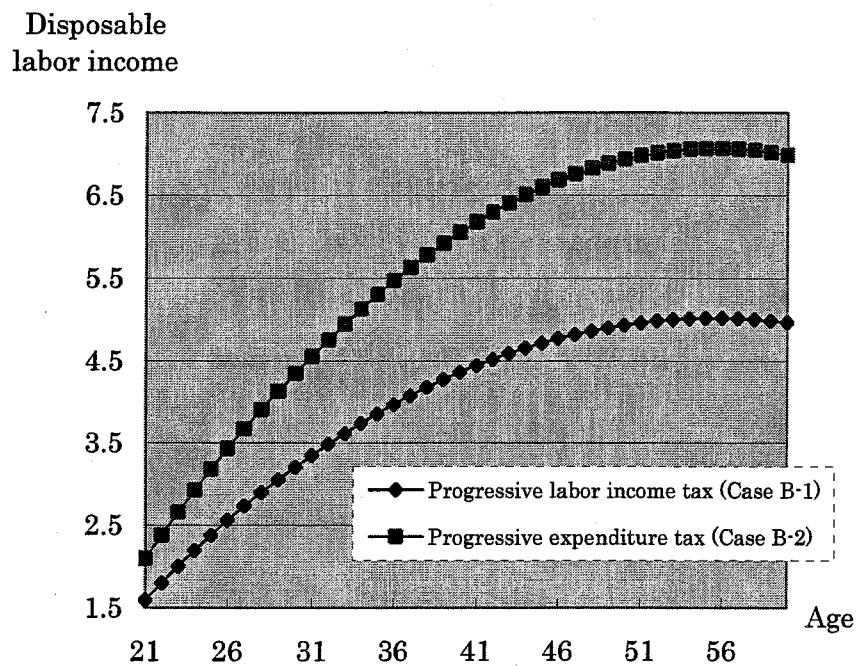


Figure 4.4 *Age-profile of disposable labor income for the high-income class in Cases B-1 and B-1**

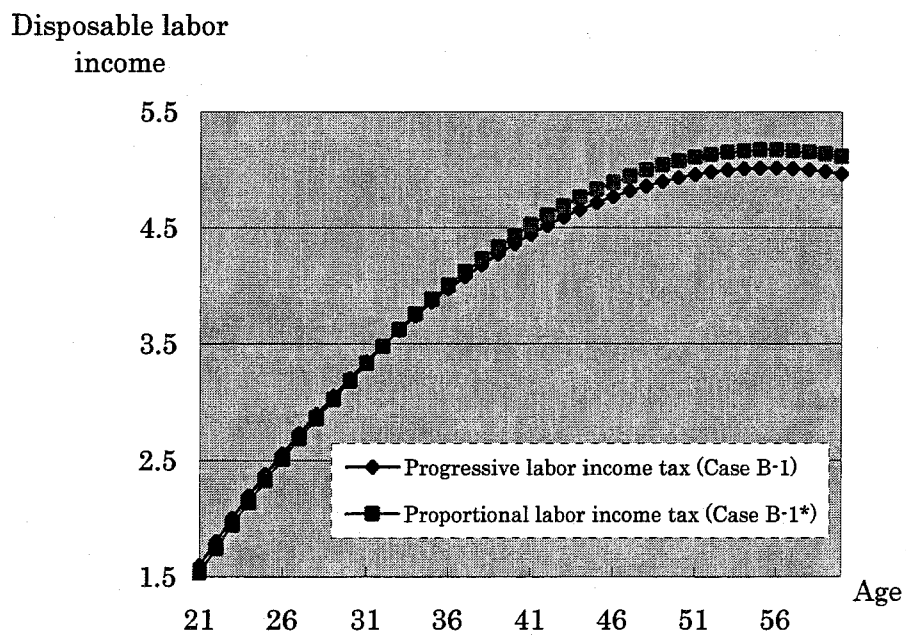


Figure 4.5 *Age-profile of consumption for the high-income class in Cases B-1 and B-2*

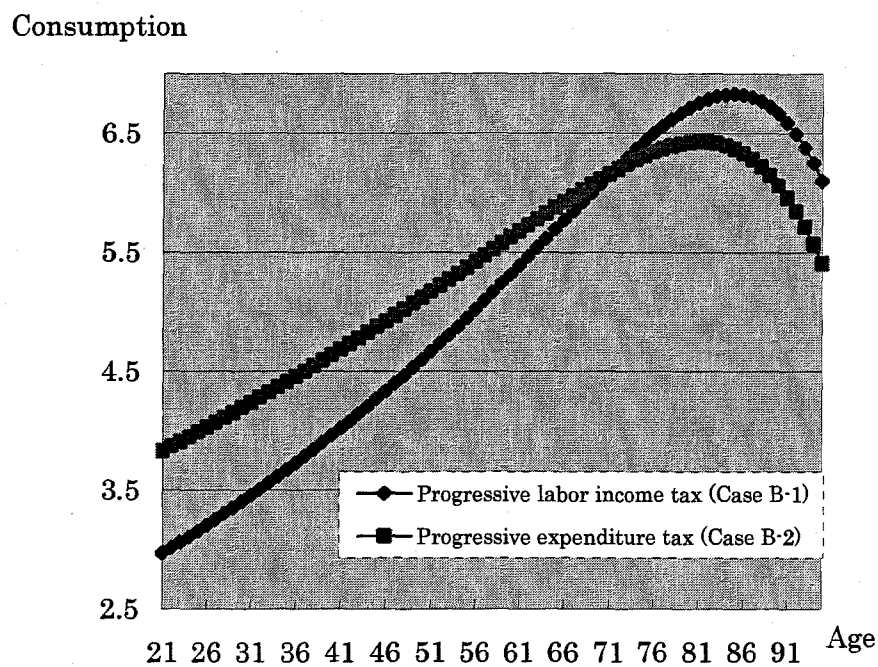
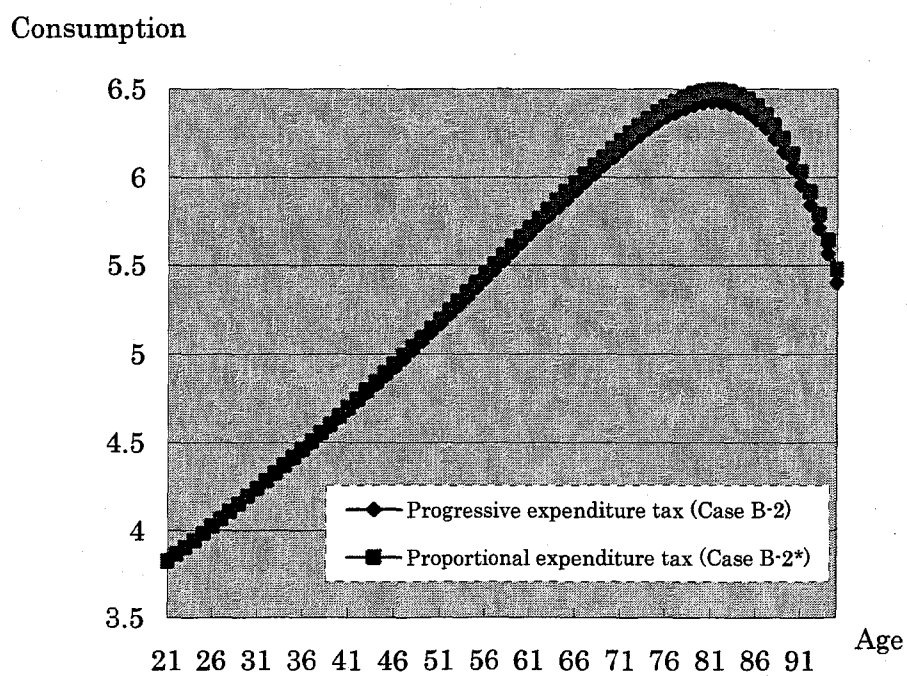


Figure 4.6 *Age-profile of consumption for the high-income class in Cases B-2 and B-2**



5 Simulating tax reforms with an inheritance tax in an aging Japan*

This chapter incorporates an inheritance tax into the simulation model employed in Chapters 3 and 4. An inheritance tax adopted here is assumed to arise from the unintended bequests consistent with uncertainty regarding the length of individual life. The problem of choosing a tax base is discussed once again in this chapter. In addition to the three taxes mentioned in Chapter 3, it includes an inheritance tax, and thus examines the effect of the four tax regimes on capital formation. It also seeks an optimum combination of tax schemes, when a progressive expenditure tax is adopted as the nucleus tax.

5.1 Introduction

The purpose of this chapter is to establish guidelines for structural tax reforms in Japan, a society with an aging population. The chapter will explore where an inheritance tax should be located in relation to other tax schemes when desirable “tax-mix” policies are considered. The appropriate combinations of four tax bases, namely, labor income, interest income, consumption, and bequests, will be investigated in a quantitative way as regards efficiency and equity, using a numerical simulation

* I am grateful for insightful comments and suggestions by Professors Toshiaki Tachibanaki (Kyoto University), Naosumi Atoda (Keio University), and Yoshibumi Aso (Keio University). I also acknowledges the financial support from the Ministry of Education, Culture, Sports, Science and Technology in Japan (the Grant-in-Aid for Encouragement of Young Scientists No.13730064).

approach. The macroeconomic and welfare effects of alternative tax regimes will be evaluated in each of two steady states, one with the current Japanese age structure and the other with the age structure projected for 2025.

Nearly all studies based on a life-cycle general equilibrium simulation model have analyzed the effects of an aging population on production and consumption, and thus on economic growth. However, it is vital to evaluate not only efficiency but also equity when dealing with tax reforms. We employ an extended life-cycle general equilibrium model of overlapping generations with the difference in earnings ability. This enables us to examine equity issues in addition to efficiency issues. Thus, this chapter should present comprehensive and useful guidelines for tax reforms.

The theme of this chapter is to handle explicitly an inheritance tax. There have been many papers that study choice of tax bases using this kind of model, for instance, Auerbach and Kotlikoff (1983a, 1983b, 1987), Auerbach *et al.* (1989), Altig *et al.* (2001), or Homma *et al.* (1987a). Nearly all of them, however, dealt with only a labor income tax, a consumption tax, and an interest income (i.e., capital income) tax. We will analyze an inheritance tax, by introducing a life-cycle model into the bequest motive and inheritances that seem to be realistic in the current Japan.¹ Empirical evidence such as Kotlikoff and Summers (1981) suggests that bequests represent an important component of national wealth. The analysis based on a model without bequests may lead to quite different results from those by one with a bequest motive. Hence, we should adopt a life-cycle model with the realistic bequest motive that prevails in the current Japan, in evaluating alternative tax schemes. In a setting with significant intergenerational transfers, we compare welfare effects of various tax systems.

This chapter is organized as follows: Section 5.2 describes the basic model employed in simulation analysis. Section 5.3 explains the method of simulation analysis and the assumptions adopted. Section 5.4 evaluates the simulation findings and discusses policy implications. Section 5.5 summarizes and concludes the chapter.

5.2 Theoretical framework

We calibrate the simulation of the Japanese economy by employing population data estimated by the Institute of Population Problems of the Ministry of Health and Welfare in 1997. The model has 75 different overlapping generations. Three types of agents are considered: households, firms, and the government. Since the basic model in this chapter is the same as Chapter 3, see *3.2 Theoretical framework* for detailed explanation. The basic structure of households is as follows.

5.2.1 Household behavior

Let $q_{j+1|j}$ be the conditional probability that a household of age $j + 20$ lives to $j + 21$. Then the probability of a household of age 21 surviving until $s + 20$ can be expressed by

$$p_s = \prod_{j=1}^{s-1} q_{j+1|j}. \quad (5.1)$$

The probability $q_{j+1|j}$ is calculated from data estimated in 1997 by the Institute of Population Problems of the Ministry of Health and Welfare. The utility function of a representative household of income class i , whose form is assumed to be time-separable, is

$$U^i = \frac{1}{1 - \frac{1}{\gamma}} \sum_{s=1}^{75} p_s (1 + \delta)^{-(s-1)} \{C_s^i\}^{1 - \frac{1}{\gamma}}, \quad (5.2)$$

where C_s^i represents consumption (or expenditure) at age $s + 20$, δ the adjustment coefficient for discounting the future, and γ the intertemporal elasticity of substitution. The superscript $i (= l, m, h)$ stands respectively for low, medium, and high-income class.

The flow budget constraint equation for each household at age $s + 20$ is

$$A_{s+1}^i = \{1 + r(1 - \tau_r)\} A_s^i + \{1 - \tau_w(w x^i e_s) - \tau_p\} w x^i e_s + b_s^i + a_s^i - \{1 + \tau_c(C_s^i)\} C_s^i, \quad (5.3)$$

where A_s^i represents the amount of assets held by the household at the beginning of age $s + 20$, r the interest rate, w the wage rate per efficiency unit of labor, and e_s

the age-profile of earnings ability for the household that belongs to the medium income class.² b_s^i is the amount of public pension benefit, and a_s^i is the amount of bequest to be inherited at age $s + 20$. $\tau_w(wx^i e_s)$ is the tax rate on labor income, $\tau_c(C_s^i)$ that on consumption, τ_r that on interest income, and τ_p is the contribution rate to a public pension scheme. x^i is the weight coefficient corresponding to the different levels of labor endowments among the three income classes. The medium income class is used as a yardstick, and thus $x^m = 1$. x^l and x^h reflect the realistic differences in earnings ability across the three income classes.

Variables related to the public pension program in a pay-as-you-go system are represented by

$$\begin{cases} b_s^i = \theta H^i & (s \geq ST) \\ b_s^i = 0 & (s < ST) \end{cases}, \quad (5.4)$$

where the age at which each household starts to receive public pension benefits is $ST + 20$, the average annual remuneration is $H^i \left(= \frac{1}{RE} \sum_{s=1}^{RE} wx^i e_s \right)$, and the replacement ratio is θ .

When BQ_t^i is the sum of bequests inherited by 50-year-old households at period t , a_{30}^i is defined by

$$a_{30}^i = \frac{(1 - \tau_h) BQ_t^i}{N_t p_{30} (1 + n)^{-29}}, \quad (5.5)$$

where

$$BQ_t^i = N_t \sum_{s=1}^{75} (p_s - p_{s+1}) (1 + n)^{-(s-1)} A_{s+1}^i,$$

N_t is the number of new households entering the economy as decision-making units at period t , n is the common growth rate of successive cohorts, and τ_h is the tax rate on the inheritance of bequests.³ In the steady state of a life-cycle growth model, the amount of inheritance received is linked to the age-profile of assets chosen by individuals.

From the utility maximization problem, the equation expressing evolution of consumption over time for each household is characterized by

$$C_{s+1}^i = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \left(\frac{1+\bar{\tau}_c(C_s^i)}{1+\tau_c(C_{s+1}^i)} \right) \right]^\gamma C_s^i. \quad (5.6)$$

If initial consumption level, C_1^i , is specified, optimal consumption behavior of all ages can be derived from equation (5.6). The amount of assets held by each household at each age can be obtained from equation (5.3). The expected lifetime utility of each household is derived from equation (5.2).

The social welfare function, which takes account of the difference in lifetime earnings ability and thus resulting the difference in the level of consumption, is given by

$$SW = q^l U^l + q^m U^m + q^h U^h, \quad (5.7)$$

where q^i ($i=l, m, h$) is the weight coefficient corresponding to the existing ratio of each income class. This function is derived from a summation of the expected lifetime utilities at age 21 for the three income classes.

As for the basic structure of firms, a single production sector is assumed to behave competitively using capital and labor subject to a constant-returns-to-scale production function. See Appendix 5.A for the basic structures of firms and the government, and market equilibrium conditions.

5.3 Simulation analysis

5.3.1 Method of simulation

The simulation model presented in the previous section is solved under a hypothesis of perfect foresight by households. Households correctly anticipate the interest, wage, and tax rates. If tax and public pension systems are determined, the model can be solved using the Gauss-Seidel method (see Appendix 5.B for the computation process).

5.3.2 Simulation cases

We consider two demographic regimes, that is, the current steady state of 2000 and the aged steady state of 2025. Case A is the benchmark of the 2000 current Japan. Case B

is the benchmark of the aged Japan projected for 2025. Cases A and B differ in the population structure. Different survival probabilities (p_s) and different growth rates of successive cohorts (n) create different age structures of the population between the two demographic regimes (see Table 5.2 for the parameter values that characterize the two steady states).

In an aged steady state, Japan faces a decline in the proportion of working population, with a subsequent decrease in aggregate output (Y_t); hence, a rise in the ratio of the total tax revenue (T_t) to aggregate output (Y_t), leads to a substantial increase in tax burden in an aged state. A consumption tax covers the extra tax burden caused by a transition from the current to the aged states, under revenue neutrality.

In Case B-1, a progressive expenditure tax covers the overall tax revenue. Cases B-2 and B-3 are the “tax-mix” cases, in which there is an inheritance tax in addition to the tax regime. The ‘Case-B’ simulations in an aged state will be focused mainly on and discussed, because we are interested in how tax reforms will affect the Japanese economy in the future. Moreover, Cases C (which consist of only proportional tax systems) are considered in an aged situation, to focus on the problem of choice of tax bases. The ‘Case-C’ simulations enable us to ascertain the clear effects of alternative tax regimes on capital accumulation.

The simulation cases employed in this chapter are as follows (see Tables 5.3 and 5.4 for the simulation cases and empirical results).

1 Case A (benchmark of the 2000 current state)

The tax system on labor income has a realistic progressiveness (see 5.3.3 *Specification of parameters* for an estimation of the parameter values that determine tax progressivity, α and β). The tax rate on consumption is 5 percent, on interest income is 20 percent, and on the inheritance of bequests is 10 percent.

2 Case B (benchmark of the 2025 aged state)

The above four tax regimes are the entirely same as in Case A. A consumption tax

covers the extra tax burden caused by a transition to an aging society.

3 Case B-1 (progressive expenditure tax)

In Case B, a *progressive expenditure tax* covers the overall tax revenue. Labor and interest incomes, and inheritance are not taxed.

4 Case B-2 ("tax-mix" policy with a 50 percent inheritance tax)

In Case B-1, a *50 percent inheritance tax* covers the overall tax revenue in addition to a progressive expenditure tax. Labor income and interest income are not taxed.

5 Case B-3 ("tax-mix" policy with a 100 percent inheritance tax)

In Case B-1, a *100 percent inheritance tax* covers the overall tax revenue in addition to a progressive expenditure tax. Labor income and interest income are not taxed.

6 Case C (benchmark under the entirely proportional tax systems)

In Case B, a proportional labor income tax replaces a progressive one. Thus, the whole tax system is made completely proportional.

7 Case C-1 (inheritance tax versus consumption tax)

In Case C, the tax rate on inheritance is raised to 50 percent, and that on consumption is reduced under revenue neutrality. Tax rates on labor income and interest income remain the same as in Case C.

8 Case C-2 (inheritance tax versus labor income tax)

In Case C, the tax rate on inheritance is raised to 50 percent, and that on labor income is reduced under revenue neutrality. Tax rates on consumption and interest income remain the same as in Case C.

9 Case C-3 (inheritance tax versus interest income tax)

In Case C, the tax rate on inheritance is raised to 50 percent, and that on interest income is reduced under revenue neutrality. Tax rates on labor income and consumption remain the same as in Case C.

10 Case C-4 (interest income tax versus labor income tax)

In Case C, the tax rate on interest income is raised to 40 percent, and that on labor income is reduced under revenue neutrality. Tax rates on consumption and

inheritance remain the same as in Case C.

5.3.3 Specification of parameters

Table 5.5 presents the parameter values used in the simulation. This chapter examines the implications of several tax policies for an aging Japanese economy. Hence, we choose parameter values realistic for the economy. In the benchmark case A, the economic variables, such as the ratio of capital to income (K/Y) or that of capital to labor (K/L), are close to actual values of 2000.

First, survival probabilities (p_s) are calculated from the *Population Projections for Japan 1996-2100*, a 1997 publication by the Institute of Population Problems of the Ministry of Health and Welfare. Our model makes no sex distinction, and so this analysis uses the male-female average values for 2000 and 2025. Based on the above data, the percentages of aged population (65 or above) to the total population (21 or above) in 2000 and 2025 are 22.04 and 33.86 percent, respectively. Common growth rates of successive cohorts (n) are chosen so that the percentages in the simulation under two demographic regimes are the same as these estimated values, respectively.

Next, the method of assigning the weight given to labor endowments for the three income classes is explained. Table 5.6 shows the data from the Ministry of Finance (2001). This table presents the effective tax rates of wageworkers on a national income tax and a residence tax, as for the case of a couple with two children. In our model, the three representative households, namely, low, medium, and high income classes, have different earnings ability. Table 5.6 suggests that each income class, which accounts for one-third of the total population, corresponds to the representative household earning 5, 7, and 10 million yen on an annual base. The weight on labor endowments for each income class corresponds to the ratio of each amount of income. The medium income class is used as a yardstick, that is, $x^m = 1$. x^l and x^h are assigned so as to reflect different earnings ability across the three income classes.

Third, the method of assigning the parameter values that determine tax

progressivity on labor income, namely, α and β , is described. Table 5.6 presents the effective tax rate calculated from a national income tax and a residence tax for each income class. The parameters on labor income in the benchmark case A are chosen, so that the effective tax rate for each income class in the simulation is close to the value indicated by Table 5.6.

Finally, the method of assigning the parameter values that determine tax progressivity on expenditure, namely, α and β , in Cases B-1, B-2, and B-3 is presented. It is difficult to make the degree of tax progressivity identical across some simulation cases with different tax structures. Hence, we have decided to assign the parameter values so that the overall tax revenue (i.e., the sum of the four kinds of tax regimes) from each income class is the same as in Case B.

For the public pension system, the replacement ratio of pension payments (θ) in Case A is chosen so that the contribution rate (τ_p) equals the actual value of 17.35 percent in employees' pension plans (*Kosei Nenkin*) in 2000.

5.4 Simulation results

The aged-state simulations in 2025 are focused mainly on and discussed below, because we are interested in how tax reforms will affect the Japanese economy in the future. Tables 5.3 and 5.4 present the simulation results in the current and aged steady states. In this chapter, the influence on capital accumulation is used as an indicator of efficiency. The reason is that under the assumption of an inelastic labor supply, the level of the total output depends solely on the level of capital stock, as indicated by equation (5.8). The social welfare function represented by equation (5.7) includes the aspects of both efficiency and equity.

5.4.1 Findings and policy implications

1 Changes in capital accumulation in a transition from the current to the aged states

First, we focus on the difference in the capital-labor ratio (K/L) between the current

and aged state cases. The ratio is equal to 3.100 in the current benchmark case A of 2000, but decreases to 2.962 in the aged benchmark case B projected for 2025. Two possible reasons are as follows. One is that in an aging society, there are many generations who dissave their assets based on the life-cycle motive. The other is that the payroll tax (i.e., contribution rate) rises sharply from 17.35 percent to 30.82 percent. Therefore, the tax policies that stimulate capital accumulation may be required in an aging society.

2 Effects of the four proportional tax regimes on capital accumulation

Next, how a choice of tax bases will affect capital accumulation is examined. In order to handle this problem, it is useful to compare simulation cases under proportional taxation (see Table 5.4). According to Auerbach and Kotlikoff (1987), the capital-labor ratio (K/L) is the highest under a consumption tax, which is followed by a labor income tax, and finally a capital income tax (i.e., an interest income tax) comes. Our simulation has obtained the same qualitative result. We have introduced the taxation on the inheritance of bequests into a life-cycle model. Where is an inheritance tax placed in this order? Our simulation results indicate that it is the second: the order of priority in a choice of tax bases is a consumption tax, an inheritance tax, a labor income tax, and an interest income tax in terms of efficiency. The capital-labor ratio (K/L) under an inheritance tax is fairly high, which is close to the ratio under a consumption tax.

Our simulations projected for 2025 lead to the results that follow. We will compare a consumption tax and the other three taxes (i.e., a labor income tax, an inheritance tax, and an interest income tax). As a consumption tax covers more part of tax revenue, capital accumulation is more enhanced and simultaneously social welfare is more improved. When comparing an inheritance tax and a labor income tax, the substitution of an inheritance tax for a labor income tax stimulates capital formation and generates a higher level of social welfare. These results indicate that a consumption tax is the

best and that an inheritance tax is superior to a labor income tax.

Therefore, it is desirable that a consumption tax ultimately covers a greater part of the total tax revenue. When there are difficulties such as political reasons in raising the tax rate on consumption, the "tax-mix" policy with an inheritance tax should be adopted because an inheritance tax enhances capital accumulation after a consumption tax. If the promotion of capital formation is significant in Japan, then the first consideration should be that a consumption tax replaces an interest income tax that badly hinders capital accumulation.

3 Progressive expenditure taxation

With the switching from Case B (i.e., the benchmark case in an aged society) to B-1 (in which a progressive expenditure tax covers the overall tax revenue), the capital-labor ratio (K/L) rises from 2.962 to 3.830. The social welfare improves from -4.723 to -4.262. Thus, Case B-1 indicates the best performance. This result shows that an expenditure tax (or a consumption tax) enhances capital accumulation; and that incorporating progressivity into an expenditure tax efficiently reduces the dispersion of lifetime income distribution. In an aging Japan where saving rates would decline, stimulating capital formation is significant; and the disparity of within-cohort inequality would be increasing, according to the findings of Ohtake and Saito (1998). Hence, we recommend a progressive expenditure tax as a final goal in an aging Japan.

Ohtake and Saito (1998) suggest that younger generations have recently tended to face a high consumption inequality from the start of their life cycle in Japan, because within-cohort inequality may be transmitted from older generations to younger ones through intergenerational transfers. This is called as the "cohort effects." In a society with a high rate of economic growth, like Japan in the High-Growth Era, differences in labor income mainly generates within-cohort inequality. However, once a society has shifted to a stable-growth economy as the current Japan, the inheritance of bequests plays more significant roles, resulting in higher cohort effects. It should be noted that

significant cohort effects are found not in income inequality but in consumption inequality. This shows that consumption rather than labor income is appropriate as a tax base for achieving the redistribution of lifetime income.

4 Changes in the size of four tax bases in a transition to an aging society

Miyajima (1986) proposes the need for the "tax-mix" policy, namely, a combination of *some* tax bases. The reason is that any *single* tax base cannot perfectly satisfy all conditions that are required to the whole tax system, because it, in reality, has some defects that are not negligible functionally or administratively. Therefore, even if a progressive expenditure tax is ultimately desirable as the nucleus tax regime, we should adopt any "tax-mix" policy as an actual policy, instead of choosing the *single* tax base.

As population aging, Japan faces a decline in the proportion of working population, resulting in a drastic decrease in aggregate labor income; hence, consumption, savings, and bequests will be also reducing, because they are arisen from labor income. In order to explore a desirable "tax-mix" policy, we investigate changes in the size of tax bases. Table 5.7 presents that the size of four tax bases (namely, labor income, interest income, consumption, and bequests) will be reducing in a transition to an aging society. The decreasing rate is the highest on labor income, which is followed by interest income, and next consumption comes. It should be noted that the decreasing rate is the smallest on the inheritance of bequests. Hence, the taxation on inheritance may be increasingly significant in an aging Japan (see Appendix 5.C for detailed explanation of why the decreasing rate in bequests is the lowest in a transition to an aging society).

5 Necessity for strengthening an inheritance tax

Cases B-2 and B-3 present the "tax-mix" policies: Case B-2 has a 50 percent inheritance tax in addition to a progressive expenditure tax, and Case B-3 a 100 percent inheritance tax. The capital-labor ratio (K/L) in Cases B-2 and B-3 is respectively 3.716 and 3.624. The social welfare in Cases B-2 and B-3 is respectively

-4.363 and -4.452. As a progressive expenditure tax accounts for a greater part of the total tax revenue, the ratio increases and the social welfare improves. Since an inheritance tax enhances capital accumulation after an expenditure tax, these "tax-mix" simulations stimulate capital formation and thus attain a substantially high social welfare.

Therefore, the combination of a progressive expenditure tax and an inheritance tax is desirable as the "tax-mix" policy. If a progressive expenditure tax is adopted as the nucleus tax regime, then the taxation on inheritance may be significant as a complement tax. This is because households allocate income into consumption (i.e., expenditure) and savings; under an expenditure tax, the part allocated to savings is not taxed at that time, but it will be taxed at a point in time when households dissave in the future; however, the bequest, which is eventually a part of being not consumed, is not taxed after all.

Hence, intergenerational transfers, namely, the inheritance of bequests, should be more strongly taxed to mitigate within-cohort inequality, especially when an expenditure tax is adopted as the nucleus tax. For reference, Ohtake and Saito (1998) propose that strengthening the redistribution system and raising inheritance taxes may enable the Japanese economy to avoid further increases in inequality.

6 Substitution between an interest income tax and an inheritance tax (or a labor income tax)

In order to investigate an optimal combination between an interest income tax and an inheritance tax (or a labor income tax), we compared the simulation results in Cases C, C-3, and C-4. The results indicate, quantitatively, that the substitution of an interest income tax for an inheritance tax (or a labor income tax) may improve social welfare in spite of a decline in the capital stock. This signifies that a low capital-labor ratio (K/L) does not always lead to a low level of social welfare. Hence, the above substitution may be useful in some cases for the improvement of social welfare.

As equation (5.6) shows, however, an interest income tax distorts the

consumption-savings behavior: a rise in the tax rate on interest income raises the relative price of future consumption for current consumption. Therefore, households maximizing their lifetime utility are likely to substitute current consumption for future consumption. In that case, the slope of the age-profile of consumption becomes gentler.

7 Economic mechanism on an inheritance tax

As for the performance of an inheritance tax, this chapter does not explain an economic mechanism underlying the simulation results.⁴ The effects of an inheritance tax need to be discussed more carefully: why does an inheritance tax substantially enhance capital accumulation? Is it the inheritance tax itself, or simply the fact that other tax rates are lower, which produces this result? Would such a result hold, irrespective of the bequest motives such as altruistic motives, strategic motives, or bequest-as-consumption motives?⁵

5.5 Conclusions

This chapter has developed, calibrated, and simulated a life-cycle general equilibrium model of overlapping generations with the difference of earnings ability, for the purpose of clarifying the guidelines for structural tax reforms. We have focused on the taxation on intergenerational transfers by introducing an unintended bequest motive into the model. The chapter has compared the macroeconomic and welfare effects of alternative fundamental tax regimes in an aging Japan.

The simulation results suggest, quantitatively, that the capital stock diminishes in a transition to an aging society. The results also indicate that a consumption tax stimulates capital accumulation and offset some of the dissaving taking place in an aging population; and a progressive expenditure tax efficiently reduces the dispersion of lifetime income enhancing overall welfare. Therefore, we recommend that progressive expenditure taxation should replace progressive labor income taxation that is the current Japanese system.

When a progressive expenditure tax is regarded as the nucleus tax regime, an inheritance tax is desirable as a complement tax. This is because an inheritance tax promotes capital formation after a consumption tax, and because it may restrain the recent Japanese tendency that younger generations face a high consumption inequality from the beginning of their life cycle. In terms of efficiency and equity, the combination of a progressive expenditure tax and an inheritance tax should be adopted as a realistic “tax-mix” policy.

Appendix 5.A

Section 5.2 describes the basic structure of households in the simulation model. This appendix presents those of firms and the government, and market equilibrium conditions:

Firm behavior

The production function is assumed to be of the constant elasticity of substitution form:

$$Y_t = B \left[\varepsilon K_t^{1-\frac{1}{\sigma}} + (1-\varepsilon) L_t^{1-\frac{1}{\sigma}} \right]^{\frac{1}{1-\frac{1}{\sigma}}}, \quad (5.8)$$

where Y_t represents the total output, K_t the total capital, L_t the total labor supply measured by the efficiency units, B a scaling constant, ε a parameter measuring the intensity of use of capital in production, and σ the elasticity of substitution between K_t and L_t . Using the property subject to a constant returns-to-scale production function, we can obtain the following equation:

$$Y_t = rK_t + wL_t. \quad (5.9)$$

Government behavior

The budget constraint of narrower government sector at time t is given by

$$G_t = T_t, \quad (5.10)$$

where G_t is government spending on goods and services in year t , and T_t is the total tax revenue from labor income, interest income, consumption, and inheritance. The public pension system is assumed to be a simple pay-as-you-go system. The budget constraint of pension sector at time t is given by

$$R_t = B_t, \quad (5.11)$$

where R_t is the total contribution to pension scheme, and B_t is the total pension benefits to generations of age $ST + 20$ and above.

G_t , T_t , R_t , and B_t are defined respectively by

$$G_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} g, \quad (5.12)$$

$$T_t = LX_t + \tau_r r AS_t + CX_t + \tau_h BQ, \quad (5.13)$$

$$R_t = \tau_p w L_t, \quad (5.14)$$

$$B_t = N_t \sum_{s=ST}^{75} p_s (1+n)^{-(s-1)} \{q^l b_s^l + q^m b_s^m + q^h b_s^h\}, \quad (5.15)$$

where g is annual government expenditure for each cohort, and

$$BQ = q^l BQ^l + q^m BQ^m + q^h BQ^h.$$

LX_t and CX_t are tax revenues respectively from labor income and consumption (or expenditure), which are led by the summation of the three income classes with the same weight:

$$LX_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} \left[q^l \left\{ \alpha w x^l e_s + \frac{1}{2} \beta (w x^l e_s)^2 \right\} + q^m \left\{ \alpha w x^m e_s + \frac{1}{2} \beta (w x^m e_s)^2 \right\} + q^h \left\{ \alpha w x^h e_s + \frac{1}{2} \beta (w x^h e_s)^2 \right\} \right], \quad (5.16)$$

$$CX_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \left[q^l \left\{ \alpha C_s^l + \frac{1}{2} \beta (C_s^l)^2 \right\} + q^m \left\{ \alpha C_s^m + \frac{1}{2} \beta (C_s^m)^2 \right\} + q^h \left\{ \alpha C_s^h + \frac{1}{2} \beta (C_s^h)^2 \right\} \right]. \quad (5.17)$$

Similarly, the total public pension benefits, B_t , aggregate assets supplied by households, AS_t , and aggregate consumption, AC_t , are obtained by a weighted summation of the three income groups:

$$AS_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \{q^l A_s^l + q^m A_s^m + q^h A_s^h\}, \quad (5.18)$$

$$AC_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \{q^l C_s^l + q^m C_s^m + q^h C_s^h\}. \quad (5.19)$$

Market equilibrium

Finally, equilibrium conditions for the capital, labor, and goods markets are described.

1 Equilibrium condition for the capital market

$$AS_t = K_t. \quad (5.20)$$

2 Equilibrium condition for the labor market

$$L_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} \{q^l x^l + q^m x^m + q^h x^h\} e_s. \quad (5.21)$$

3 Equilibrium condition for the goods market

$$Y_t = AC_t + (K_{t+1} - K_t) + G_t. \quad (5.22)$$

An iterative program is performed to obtain the equilibrium values of the above equations.

Appendix 5.B

If tax and public pension systems are determined, the simulation model presented in Section 5.2 can be solved using the Gauss-Seidel method. The outline of a computation process is as follows.

Step 1

The interest rate r^0 , the wage rate w^0 , the bequest amount for each income class $(a^i)^0$, the tax rate on interest income τ_r^0 , and the contribution rate to a public pension scheme τ_p^0 are chosen as initial values.

Step 2

Each household that maximizes the lifetime utility determines the time paths of consumption $(C^i)^1$ and savings $(S^i)^1$ for an entire life cycle, by taking the previous values and the tax rates on labor income $\tau_w(wx^i e_s)$, consumption $\tau_c(C_s^i)$, and

inheritance τ_h as given.

Step 3

Aggregate capital K^1 is obtained by summing the assets of all overlapping generations existing at a given period for each income class, and by adding up the total assets $(A^i)^1$ for the three income groups giving them the same weight. Then, the production equilibrium conditions, which are led by equation (5.8), bring about a new interest rate r^1 and a new wage rate w^1 . For each income class, the sum of bequests $(BQ^i)^1$ is derived from the class's total assets $(A^i)^1$, which generates a new amount of bequest $(a^i)^1$.

To balance the narrower government sector account, the tax rate on interest income changes to τ_r^1 . In a similar way to the balance of the public pension sector account, the contribution rate changes to τ_p^1 .

Step 4

Using r^1 , w^1 , $(a^i)^1$, τ_r^1 , and τ_p^1 as new initial values, we return to Step 1. This method is iterated until stable variables (or equilibrium) are obtained.

Appendix 5.C

Table 5.7 demonstrates that the decreasing rate of the total assets (i.e., the capital stock) is higher than that of labor income. In other words, it is the most drastic for capital accumulation. Nevertheless, the tax base of interest income does not decrease so much. This may be dependent on the definition that interest income is the product of total assets multiplied by an interest rate. The interest rate in the simulation is higher in an aged situation than in a current situation, because capital is relatively rare to labor in an aging society.

Next, we examine the reason why the decreasing rate in the total bequests is the lowest in a transition to an aging society, although the decreasing rate in assets is the highest. Our model has unintended bequests caused by uncertainty over the length of life. The bequests, which were held as assets by deceased households, are handed to

surviving 50-year-old households that belong to the same income class. Hence, the overall amount of bequests is closely in connection with assets (see Figure 5.1 for the age-profiles of assets in the current and aged steady states).

As indicated by equation (5.5), the value of $p_s - p_{s+1}$ plays an important role for an outbreak of unintended bequests. Since the expected survival probabilities at old ages are higher in 2025 than in 2000, households may accumulate more assets during their life cycle. Figure 5.2 suggests that the peak of values of $p_s - p_{s+1}$ is placed at older ages in 2025 than in 2000 and that the values after the age 89 are higher in 2025 than in 2000. Therefore, individual assets are likely to change into bequests rapidly after 89 in an aging society. This observation may explain the reason why a decreasing rate in bequests is lower than that in the other three tax bases.

Table 5.1 *Estimation of the age-profile of earnings ability*

a_0	a_1	a_2	a_3	a_4
-0.680796 (-1.73253)	0.111582 (4.04878)	-0.0013685 (-5.32310)	0.104218 (2.93608)	-0.0008368 (-0.91418)

$$\begin{cases} S.E. = 0.0534 \\ R^2 = 0.9975 \end{cases}$$

Table 5.2 *Parameter values that characterize the two steady states*

	Current steady state (Case A)	Aged steady state (Cases B and C)
Survival probabilities (p_s)	2000	2025
Growth rate of successive cohorts (n)	0.01056	-0.00515
New entrants in period t (N_t)	1.5	0.9154
Labor supply (L_t)	153.22	132.51
Contribution rate (τ_p)	0.1735	0.3082

Table 5.3 *Current and aged benchmark cases and empirical results caused by some tax reforms in the 2025 aged steady state*

<i>Case</i>	A (Benchmark; current state)	B (Benchmark; aged state)	B-1 (Progressive expenditure tax)	B-2 (Tax-mix; 50% inheritance tax)	B-3 (Tax-mix; 100% inheritance tax)
Tax rate on labor income ($\tau_w(wx^i e_s)$)	* $\begin{cases} \alpha = -0.040 \\ \beta = 0.0540 \end{cases}$	* $\begin{cases} \alpha = -0.040 \\ \beta = 0.0540 \end{cases}$	*0	*0	*0
Tax rate on consumption ($\tau_c(C_s^i)$)	* $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.0677 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.0596 \\ \beta = 0.0889 \end{cases}$	* $\begin{cases} \alpha = 0.0324 \\ \beta = 0.0856 \end{cases}$	* $\begin{cases} \alpha = 0.0087 \\ \beta = 0.0828 \end{cases}$
Tax rate on interest income (τ_r)	0.2000	0.2000	0.0000	0.0000	0.0000
Tax rate on inheritance (τ_h)	*0.1	*0.1	*0	*0.5	*1
Capital-labor ratio (K/L)	3.100	2.962	3.830	3.716	3.624
Interest rate (r)	0.0378	0.0405	0.0275	0.0288	0.0299
Wage rate (w)	0.9970	0.9890	1.0324	1.0275	1.0235
(Low) Utility (U^l)	-5.122	-10.233	-9.435	-9.657	-9.852
(High) Utility (U^h)	-0.423	-0.901	-0.706	-0.723	-0.738
Social welfare (SW)	-2.343	-4.723	-4.262	-4.363	-4.452

Note: Asterisks (*) before the rate indicate that the variable is exogenous.

Table 5.4 *Effects of alternative tax bases on capital accumulation in the 2025 aged steady state under proportional taxation*

Case	C (Benchmark: Proportional tax)	C-1 (Inheritance tax vs. Consumption tax)	C-2 (Inheritance tax vs. Labor income tax)	C-3 (Inheritance tax vs. Interest income tax)	C-4 (Labor income tax vs. Interest income tax)
Tax rate on labor income (τ_w)	0.0630	*0.0630	0.0414	*0.0630	0.0379
Tax rate on consumption (τ_c)	*0.0677	0.0470	*0.0677	*0.0677	*0.0677
Tax rate on interest income (τ_r)	*0.2000	*0.2000	*0.2000	0.0057	*0.4000
Tax rate on inheritance (τ_h)	*0.1	*0.5	*0.5	*0.5	*0.1
Capital-labor ratio (K/L)	2.751	2.706	2.891	2.927	2.705
Interest rate (r)	0.0452	0.0463	0.0420	0.0412	0.0463
Wage rate (w)	0.9756	0.9726	0.9846	0.9869	0.9725
(Low) Utility (U^l)	-13.364	-13.599	-12.715	-13.501	-12.664
(High) Utility (U^h)	-0.835	-0.850	-0.795	-0.844	-0.792
Social welfare (SW)	-5.893	-5.996	-5.606	-5.953	-5.584

Note: Asterisks (*) before the rate indicate that the variable is exogenous.

Table 5.5 *Parameter values used in simulation analysis*

	Parameter values
Adjustment coefficient for discounting the future	$\delta = -0.022$
Intertemporal elasticity of substitution	$\gamma = 0.2$
Elasticity of substitution in production	$\sigma = 0.6$
Weight parameter in production	$\varepsilon = 0.2$
Scale parameter in production	$B = 0.942$
Government expenditure for each cohort	$g = 0.3111$
Retirement age	$RE = 40$
Starting age for receiving public pension	$ST = 45$
Replacement ratio for public pension	$\theta = 0.5512$

Table 5.6 *Effective tax rates of wageworkers on a national income tax and a residence tax (case of a couple with two children)*

<i>Income class</i>	Total amount of annual income (million yen)	Weight on labor endowments	Total amount of annual taxes: national income tax and residence tax (thousand yen)	Effective tax rates (%)	Proportion of the income class
Low	5	$x^l = 0.7143$	115	2.30	$q^l = 0.3333$
Medium	7	$x^m = 1$	319	4.56	$q^m = 0.3333$
High	10	$x^h = 1.4286$	859	8.59	$q^h = 0.3333$

(Source: <http://www.mof.go.jp/jouhou/syuzei/siryou/kozin/kozi09.htm>, Ministry of Finance, Japan (2001).)

Table 5.7 *Changes in the size of four tax bases in a transition from the 2000 current to the 2025 aged steady states*

<i>Tax base</i>	<i>Current benchmark case A (2000)</i>	<i>Aged benchmark case B (2025)</i>	<i>Rate of change (%)</i>
Labor income (wL)	152.76	131.05	-14.21
Interest income (rK)	17.96	15.89	-11.56
Consumption (AC)	144.85	128.23	-11.47
Bequests (BQ)	7.702	6.869	-10.82
Interest rate (r)	0.0378	0.0405	7.02
Capital stock (K)	474.94	392.46	-17.36

Figure 5.1 *Age-profiles of assets for the high-income class in Cases A and B*

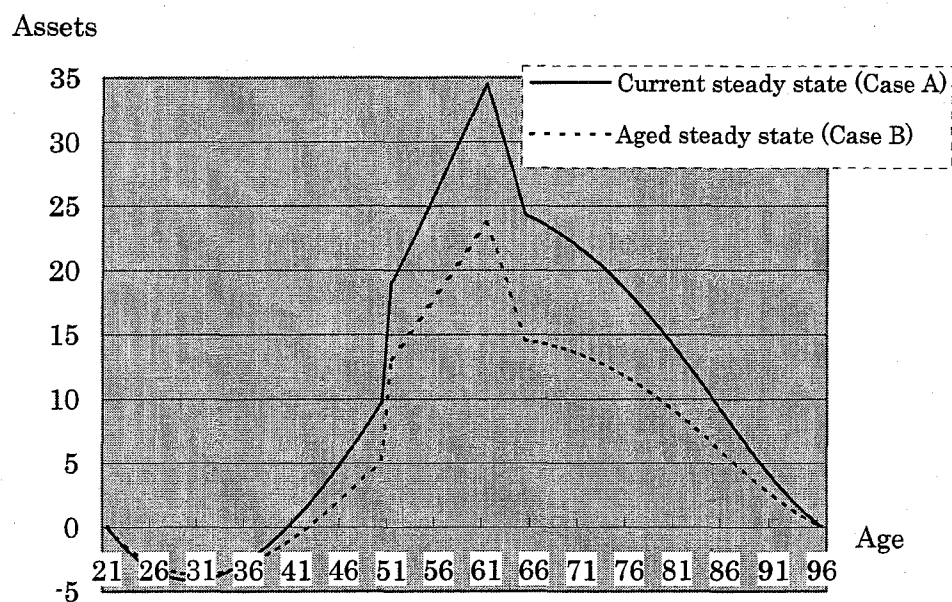
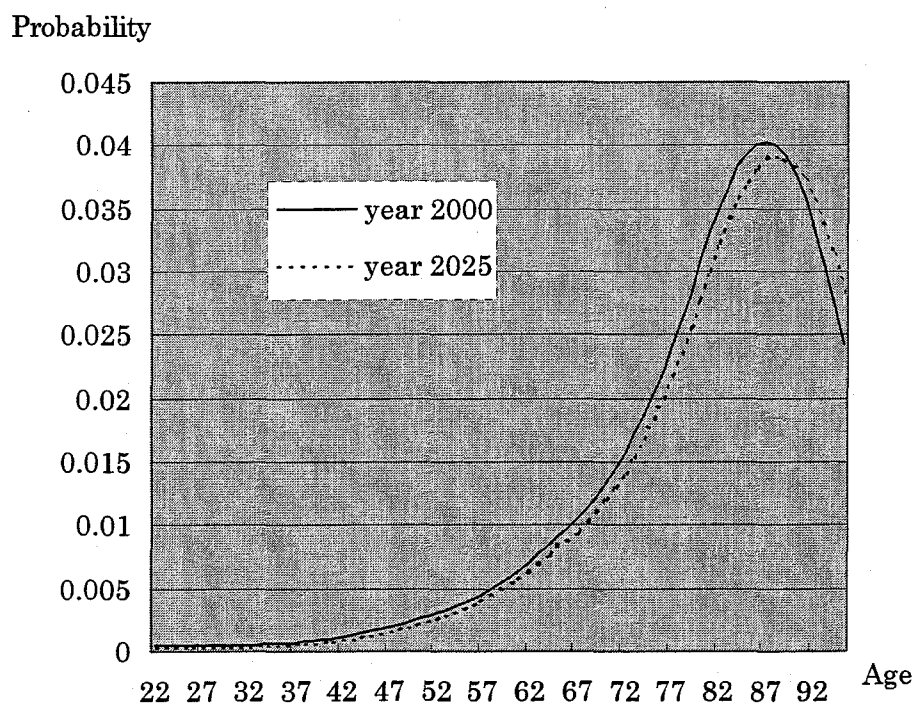


Figure 5.2 *Changes in the conditional probability that a surviving household dies next year*



6 Integration of tax and social security systems

On the financing methods of a public pension scheme in a pay-as-you-go system*

The purpose of this chapter is to establish guidelines for structural reforms of tax and social security systems in an aging Japan. In the simulation model employed in the earlier chapters, this chapter introduces basic pension into the public pension system. The empirical aspect is intensified in this chapter; most of the parameter values are calibrated based on the data prepared by the Japan Cooperative Association. The chapter incorporates 275 representative households with unequal incomes, which are estimated using this data.

6.1 Introduction

One of the most serious social and economic problems in Japan is an aging population. Drastic reforms in both the tax and social security systems accommodating this drastic structural change have become an urgent policy issue. This study proposes the guidelines for such reforms in Japan. The purpose of this chapter is as follows. First, we investigate whether or not the integration of tax and social security (in particular,

* An early version of this chapter was presented at the *53rd Congress of the International Institute of Public Finance (IIPF)* at Ritsumeikan University, the *1997 Annual Meeting of the Japan Association of Economics and Econometrics* at Waseda University, the *International Conference on Social Security Reform in Advanced Countries* at the University of Tokyo in 1999, and the *2000 Annual Meeting of the Japan Fiscal Science Association (Nihon Zaisei Gakkai)* at Meikai University. We are grateful for insightful comments and suggestions by Professors Naosumi Atoda, Bev Dahlby, Yoshibumi Aso, Yukinobu Kitamura, Shigeki Kunieda, Masahiro Hidaka, Kyoji Hashimoto, Takao Fujimoto, and Shoji Haruna. We acknowledge the financial support from The Zengin Foundation for Studies on Economics and Finance.

pay-as-you-go public pension) systems is desirable as regards efficiency and equity. Second, we evaluate what tax base (e.g., a progressive labor income tax, a proportional or progressive expenditure tax, and their combination) is preferable in the integration case.

Here, the implication of “integration” used in this chapter will be explained. The chapter does not address a problem with integration itself, such as a cost reduction by making two organizations one. We focus on the fact that the general government tax revenue currently covers one-third of the flat part (i.e., the basic pension) of public pension benefit in Japan, instead of the contributions to a public pension program. We explore whether or not the ratio of one-third should be raised, to establish the guidelines for structural reforms in the short term. We also investigate whether or not general taxes should cover not only the flat part but also the part proportional to remuneration for each individual, to obtain the guidelines in the long term. Moreover, we evaluate what tax base is the best in terms of efficiency and equity, if it is desirable that the general tax covers a greater part of public pension benefit.

The crucial point is that the contributions to public pension scheme in the pay-as-you-go system in Japan essentially mean a proportional labor income tax. Hence, even if a proportional labor income tax replaces the contributions, this alternation would not affect economic variables such as the capital stock or the redistribution of income. Other taxes, for instance, a progressive labor income tax, a proportional or progressive expenditure tax, and their combination, have an influence on efficiency or equity. Thus, the term “integration” is employed, because we consider that general taxes replace the contributions along the lines of the current tax and social security systems in Japan.

There are two themes in this chapter.

First, the public pension system in this chapter is more realistic than the earlier studies such as Homma *et al.* (1987a) or Kato (1998). In those papers, the public pension system consists of only the part proportional to remuneration of each

household, and the public pension sector is financed independently and separately from the narrower government sector. By contrast, this chapter incorporates the basic pension into the public pension system, and one-third of the basic pension is covered or transferred from general tax revenues.

Second, this chapter lays a special emphasis on an empirical aspect. The parameter values assigned in the simulation are estimated using the data, The *Household Expenditure Survey 1995* by the Japan Cooperative Association. We will incorporate 275 representative households with the difference in the lifetime earnings ability, which are obtained by the data. This permits us to undertake analysis in a model with a greater similarity to the real world.

This chapter is organized as follows: Section 6.2 identifies the basic model employed in simulation analysis. Section 6.3 explains the method of simulation analysis and the assumptions adopted. Section 6.4 evaluates the simulation findings. Section 6.5 summarizes and concludes the chapter, and discusses the policy implications.

6.2 Theoretical framework

We calibrate the simulation of the Japanese economy by employing population data estimated by the Institute of Population Problems of the Ministry of Health and Welfare in 1992. The model has 75 different overlapping generations. Three types of agents are considered: households, firms, and the government. Since the basic model in this chapter is the same as in Chapter 3, see *3.2 Theoretical framework* for detailed explanation. The basic structure of households is as follows.

6.2.1 Household behavior

Households are divided into 275 income classes: from the lowest to the highest income class. A single household type represents each income class. Let $q_{j+1|j}$ be the conditional probability that a household of age $j + 20$ lives to $j + 21$. Then the

probability of a household of age 21 surviving until $s + 20$ can be expressed by

$$p_s = \prod_{j=1}^{s-1} q_{j+1|j} . \quad (6.1)$$

The probability $q_{j+1|j}$ is calculated from data estimated in 1992 by the Institute of Population Problems of the Ministry of Health and Welfare.

The utility function of a representative household of income class i , whose form is assumed to be time-separable, is

$$U^i = \frac{1}{1 - \frac{1}{\gamma}} \sum_{s=1}^{75} p_s (1 + \delta)^{-(s-1)} \left\{ C_s^i \right\}^{1 - \frac{1}{\gamma}} , \quad (6.2)$$

where C_s^i represents consumption (or expenditure) at age $s + 20$, δ the adjustment coefficient for discounting the future, and γ the intertemporal elasticity of substitution on consumption. The superscript i ($= 1, 2, \dots, 275$) denotes from the lowest to the highest income class in numerical order.

The flow budget constraint equation for each household at age $s + 20$ is

$$A_{s+1}^i = \{1 + r(1 - \tau_r)\} A_s^i + \{1 - \tau_w(wx^i e_s) - \tau_p\} wx^i e_s + b_s^i + a_s^i - \{1 + \tau_c(C_s^i)\} C_s^i , \quad (6.3)$$

where A_s^i represents the amount of assets held by the household at the beginning of age $s + 20$, r the interest rate, w the wage rate per labor efficiency unit, and e_s the age-profile of earnings ability. x^i is the weight coefficient corresponding to the different levels of labor endowments among the income classes. b_s^i is the amount of public pension benefit, and a_s^i is the amount of bequest to be inherited at age $s + 20$. $\tau_w(wx^i e_s)$ is the tax rate on labor income, $\tau_c(C_s^i)$ that on consumption, and τ_r that on interest income. τ_p is the contribution rate to a public pension program in a pay-as-you-go system.

The public pension program is assumed to be a pay-as-you-go system that is close to the current Japanese system. The system consists of the basic pension (i.e., the flat part) and a part proportional to the average annual remuneration for each household.

Variables related to the system are represented by

$$\begin{cases} b_s^i = f + \theta H^i & (s \geq ST) \\ b_s^i = 0 & (s < ST) \end{cases} , \quad (6.4)$$

where the age at which each household starts to receive public pension benefit is $ST + 20$, the average annual remuneration is $H^i \left(= \frac{1}{RE} \sum_{s=1}^{RE} wx^i e_s \right)$, the basic pension benefit is f , and the weight coefficient of the part proportional to H^i is θ . Thus, b_s^i reflects the difference in the ability of labor supply among the 275 income classes.

When BQ_t^i is the sum of bequests inherited by 50-year-old households at period t , a_{30}^i is defined by

$$a_{30}^i = \frac{BQ_t^i}{N_t p_{30} (1+n)^{-29}}, \quad (6.5)$$

where

$$BQ_t^i = N_t \sum_{s=1}^{75} (p_s - p_{s+1}) (1+n)^{-(s-1)} A_{s+1}^i,$$

N_t is the number of new households entering the economy as decision-making units at period t , and n is the common growth rate of successive cohorts.

From the utility maximization problem, the equation expressing evolution of consumption over time for each household is characterized by

$$C_{s+1}^i = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \left(\frac{1+\tau_c(C_s^i)}{1+\tau_c(C_{s+1}^i)} \right) \right]^\gamma C_s^i. \quad (6.6)$$

If the level of initial consumption, C_1^i , is specified, optimal consumption behavior of all ages can be derived from equation (6.6). The amount of assets held by each household for all ages can be obtained from equation (6.3). The expected lifetime utility of each household is derived from equation (6.2).

The social welfare function, which takes account of heterogeneity in the ability of labor forces and thus resulting distribution of consumption, is given by

$$SW = \sum_{i=1}^{275} U^i. \quad (6.7)$$

This function is obtained by a simple summation of the expected lifetime utilities of the 275 income classes.

As for the basic structure of firms, a single production sector is assumed to behave competitively using capital and labor, subject to a constant-returns-to-scale production

function. See Appendix 6.A for those of firms and the government, and market equilibrium conditions.

6.3 Simulation analysis

6.3.1 Method of simulation

Five cases in the steady state in 1995 are considered under balanced budget policies. The assumption of tax revenue neutrality is normally imposed for a tax model to ascertain the clear effects of tax reforms. Our study, however, intends to substitute general taxes for the contributions to public pension scheme. Hence, it is impossible to hold the total tax revenue, namely, $T_t(\tau)$, constant across cases. We decided to keep the general government spending except for a transfer to public pension sector, namely, $G_t(g)$, constant among all cases. (see Appendix 6.A for the definition of $T_t(\tau)$ and $G_t(g)$).

The size of population is the same in all cases, and general government expenditure per capita, g , is exogenously given as a constant. Thus, the general government spending, G_t , is exogenous and unchanged across all cases. Since the total tax revenue, $T_t(\tau)$, consists G_t and a transfer to the public pension scheme as indicated by equation (6.10), $T_t(\tau)$ in each case depends on the degree of the transfer.

For the tax system, the tax rates on labor income, $\tau_w(wx^i e_s)$, and consumption, $\tau_c(C_s^i)$, are exogenously given, resulting in the endogenous tax rate on interest income, τ_r . For the public pension system, the amount of the basic pension per capita, f , and the weight coefficient of the part proportional to remuneration for each individual, θ , are exogenously given. Hence, the contribution rate to a public pension scheme, τ_p , is made endogenous.

6.3.2 Five cases for simulations

Five cases are considered for our simulation. Case A is the benchmark in 1995, where

there is the realistic progressive tax system on labor income, and the tax rate on consumption is 5 percent and that on interest income 20 percent. Cases B and C carry out partial integration, which will give us the reform guidelines in the short term. Cases D and E execute perfect integration, which will indicate the reform guidelines in the long term.

1 Case A (benchmark)

The case reflects the fact in 1995 that the general tax revenue covers one-third of the basic pension in the public pension system.

2 Case B (partial integration and a progressive labor income tax)

The rate of tax transfer is raised from one-third to a half (i.e., a rise of one-sixth of the basic pension),¹ and the extra tax burden accompanied is covered by a progressive labor income tax. In other words, public pension contributions, which mean a *proportional* labor income tax, are substituted by a *progressive* labor income tax. Under tax revenue neutrality, the adjustment in tax parameters on labor income is made only by the part proportional to labor income, β , holding the constant term, α , unchanged.

3 Case C (partial integration and a proportional consumption tax)

The rate of tax transfer is raised from one-third to a half (i.e., a rise of one-sixth of the basic pension), and the additional tax burden accompanied is covered by a proportional consumption tax. In other words, public pension contributions, which signify a proportional *labor income tax*, are substituted by a proportional *consumption tax*.

4 Case D (perfect integration and a proportional expenditure tax)

The tax revenue covers the total public pension payments that consist of the basic pension and the part proportional to remuneration for each individual. The source of overall tax revenue is only a *proportional* expenditure tax. Labor income and interest income taxes are eliminated.

5 Case E (perfect integration and a progressive expenditure tax)

In Case D, a *progressive* expenditure tax replaces a proportional one. The degree of tax progressivity on expenditure is assigned in the method that follows. The constant term, α , is half of that in Case D, and the parameter of a part proportional to expenditure, β , is adjusted under tax revenue neutrality.

Empirical evaluation of each simulation from Case B to E in comparison with the benchmark case A is made by the following formulation of *RWC* (relative welfare changes by percentage figures):

$$RWC = \frac{-100 \times (U_j - U_A)}{U_A}, \quad (6.23)$$

where U_A signifies each household's utility in Case A, and U_j ($j = B, C, D, E$) means that in each simulation. The minus sign was added so that improvements in *RWC* show positive numerical changes in welfare.

6.3.3 Data and parameter values

The household expenditure survey in 1995, which was collected and classified by the Japan Cooperative Association, is used as a data source. This survey reports each household's income, consumption, tax, social security benefit and contributions, etc. The number of observations is 275, which enables us to evaluate changes in welfare of each household caused by tax and public pension reforms. A rigorous quantitative examination on the changes is feasible, provided that we can get the realistic figures concerning the various parameter values such as each household's labor endowments or taxes. The process for estimation of parameter values employed in simulation analysis is presented and discussed (see Table 6.1 for the assignment of parameter values).

1 Weight on labor endowments for each income class

The original survey included 363 households. Some of them are retired households

that do not work, and thus their consumption is based on the pension benefits and dissavings from their accumulated wealth. Since the starting age of receiving public pension benefits is currently 60, RE (i.e., the parameter of retirement age) can be specified as 39. The retired household whose head is older than 59 is removed, resulting in the 276 working households. However, one particular household's annual revenue is ¥678,350, which is below the subsistence level, while this household gets a high amount of rent income, ¥5,803,760. This sample was excluded, because it is not appropriate to include it for the purpose of estimating labor endowments for each income class. As a result, the total number is 275, which enables us to estimate the labor endowments.

Figure 6.1 shows the distribution of households' annual labor income, which is defined by the following formulation:

$$\begin{aligned} \text{Labor income of a household} = & \text{husband's wage} + \text{wife's wage} + \text{husband's bonus} + \\ & \text{wife's bonus} + \text{self-employed income} + \text{in-house revenue} + \text{other family members' revenue.} \end{aligned} \quad (6.A)$$

The average labor income is ¥7,928,220 with its minimum ¥2,521,740 and maximum ¥17,193,603. By dividing each labor income by its average and thus normalizing each labor income, each weight on labor endowments, x^1, x^2, \dots, x^{275}

$\left(\text{with } \sum_{i=1}^{275} x^i = 275 \right)$, can be estimated.

2 Estimation of the age-profile of earnings ability, e_s

Figure 6.2 indicates the distribution of households' age-annual labor income. By regressing on x^i with the independent variables being each household's age and its squared form, it is possible to estimate the age-profile of labor efficiency, e_s . The results estimated by the OLS method are presented in Table 6.2.

3 Estimation of the parameters of tax progressivity on labor income, α and β

The average tax rate on labor income is $\tau_w = \alpha + \frac{1}{2}\beta(wx^ie_s)$, as shown in Section 6.2.

The estimation of parameters, α and β , in the benchmark case A, was undertaken in the way that follows. First, the tax burden on labor income of each household is calculated by the following formulation:

$$\begin{aligned} \text{Labor income tax burden of a household} = & \text{husband's national income tax} + \text{wife's} \\ & \text{national income tax} + \text{husband's local income tax} + \text{wife's local income tax.} \end{aligned} \quad (6.B)$$

By dividing equation (6.B) by equation (6.A), it is possible to get the tax rate on labor income for each household. The parameters, α and β , are estimated by the OLS method for the following regression equation. As Table 6.3 suggests, the dependent variable is the tax rate on labor income, and the independent variable is half of x^i . Table 6.4 presents the assignment of parameter values, α and β , in each simulation case.

Two notes are added. First, the regression equation ignores the weighting factors, w and e_s , but $w e_s$ is, of course, not always equal to unity. The value of a scale parameter in production, Q , is chosen so that the ratio of labor income tax revenue to labor income at a macro level equals the realistic value of 6.678 percent. Second, a negative value of α includes the possibility of negative tax rates for some poor households. When negative tax rates were obtained for some households, we took the zero rates.

4 Estimation of the parameters for the public pension program

In the model, public pension benefit consists of the flat part, namely, the basic pension, and a part proportional to remuneration for each household. Under the current Japanese system, the general tax revenue covers one-third of the flat part, and the public pension contributions cover both the remaining two-thirds and the overall proportional part. Hence, μ in equations (6.10) and (6.11) is assigned to $\frac{1}{3}$ in the

benchmark case A. This rate for other simulations is changed to show desirable policy reforms. In the cases of partial integration, B and C, μ is assigned to $\frac{1}{2}$. In the cases of full integration, D and E, the following equation (6.10)' replaces equations (6.10), (6.11), (6.13), (6.14), and (6.15):

$$T_t = G_t + B_t, \quad (6.10)'$$

where $B_t = N_t \sum_{s=ST}^{75} \left\{ p_s (1+n)^{-(s-1)} \sum_{i=1}^{275} b_s^i \right\}.$

The *White Paper on Welfare 1996* published by the Ministry of Welfare suggests that the monthly amount of basic pension for an individual is ¥65,458, and thus the annual benefit for a couple is ¥1,570,992. Since ¥7,928,220 is assumed to be standard in our simulation model, the value of a normalized parameter, f (the amount of basic pension per capita), is derived. The weight coefficient of the part proportional to remuneration, θ , is chosen so that the contribution rate in the benchmark case A equals the 1995 value of 16.5 percent in employee's pension plans (*Kosei Nenkin*) in 1995.

5 Adjustment coefficient for discounting the future, δ

The parameter value of δ is adjusted so that individual consumption-savings behavior in the simulation is consistent with the actual relative scale of capital stock at a macro level. The value, δ , is determined so that the capital-income ratio (K/Y) in the simulation equals 2.58, which is suggested by the *Annual Report on National Accounts 1996* published by the Economic Planning Agency.

6 Growth rate of successive cohorts, n

According to the *Population Projections for Japan 1991-2090*, a 1992 publication by the Institute of Population Problems of the Ministry of Health and Welfare, the ratio of population of 65 and above to the population of 21 and above is estimated to be 19.2 percent in 1995. The parameter value of n is chosen under the given survival probabilities, p_s , in 1995, so that the ratio in the simulation equals the estimated

value of 19.2 percent.

7 Number of overlapping generations

In the case of an overlapping generations model with 80-period life cycles, where households can live to a maximum of 100, households borrow money after 90. The reason is that at the final stage of old age, the weight on consumption in the utility function is much reduced because of a drastic decrease in expected survival probabilities. Hence, it leads to the low level of consumption, which is lower than the amount of public pension benefit. It is possible to rule out such borrowing behavior at the final stage, by assuming a 75-period model with a maximum survival age of 95 as in this chapter.

6.4 Simulation results

6.4.1 Simulation results and their interpretation

Before presenting the simulation results, the indexes of efficiency and equity employed in this chapter are explained. The influence on capital accumulation is used as an indicator of efficiency. This is because under the assumption of an inelastic labor supply, the level of total output depends only on the level of capital stock, as indicated by equation (6.8). The social welfare function represented by equation (6.7) is mainly used as an indicator of equity. However, we should keep in mind that the function depends on not only the aspect of equity but also that of efficiency. Table 6.4 presents the numerical results of each simulation. Figures 6.3 and 6.4 are the graphical representations of Cases B and C, and of Cases D and E, respectively.

The overall result suggests that Case E achieves the best performance, where perfect integration of tax and public pension systems is implemented and a progressive expenditure tax is introduced. This conclusion is derived from two observations. One is that, the highest value of 5.80 is attained for the capital-labor ratio (K/L) among all the simulation cases. The other is that, the highest improvement of -79595 is achieved for the level of social welfare among all the simulations. Moreover, the individual

change in welfare is positive for all households. The reasons why Case E is chosen as the most desirable policy reform will be explained in detail.

First, policy reforms in the short-term view along the lines of the current Japanese system are examined, through comparing Cases B and C. The transition from Case A to B means that a proportional labor income tax is substituted by a progressive labor income tax, because the contributions to public pension scheme have the same implication as a proportional labor income tax. The social welfare level of -90977 in Case B is higher than -93351 in Case A, which shows that the transition from proportionality to progressivity brings forth better outcomes in terms of equity. The transition from Case A to C signifies that a proportional labor income tax is substituted by a proportional consumption tax. The capital-labor ratio (K/L) of 3.21 in Case C is greater than 3.09 in Case A, which indicates that the substitution leads to better outcomes as regards efficiency. This is because a consumption tax burden continues to exist even after retirement, and thus it requires individuals to have a larger amount of savings than a labor income tax under tax revenue neutrality.

According to the simulation results of Cases B and C, the move from public pension contributions to taxes, whether it is a progressive labor income tax or a proportional consumption tax, improves the overall welfare of the economy: the social welfare is -90977 and -91773, respectively. The capital-labor ratio (K/L) of 3.21 in Case C is larger than 3.13 in Case B, which shows that Case C is better than Case B from the resource allocation perspective, namely, efficiency. By contrast, Case B is superior to Case C in terms of equity perspective: the welfare level for lower-income households in Case B ameliorates by from 3 to 4.5 percent increase, but deteriorates for higher-income households by from 3 to 6 percent decrease. If a society has a consensus on a further redistribution from higher-income households to lower-income ones, Case B may be preferable.

We cannot, nevertheless, ignore the fact that Case C increases the individual welfare for all households by approximately 1.5 percent. A subjective judgment is

required to select either Case B, which indicates a further redistribution, or Case C, which shows more capital accumulation and an increase in welfare for each household. Under an aging trend in the population structure, the aggregate household saving rate will decline, resulting in a less capital accumulation. This is because the trend will diminish the ratio of younger households in their accumulation phase to older households in their dissaving phase, based on the life-cycle motive. The choice of a consumption tax instead of a labor income tax may avoid this decrease in capital accumulation. Unless a society has a high preference for a further redistribution, the policy reform represented by Case C should be adopted in the short term, especially in an aging society.

Second, we investigate policy reforms in the long-term view, through comparing Cases D and E. In both of the cases, the whole public pension payments in addition to the general government expenditure are covered only by an expenditure (or consumption) tax. The simulation results of Cases D and E indicate a large increase in the capital-labor ratio (K/L) (5.57 and 5.80, respectively), which means significant contribution to capital accumulation. Thus, both of the cases are desirable in terms of efficiency. Case D, where a proportional expenditure tax covers the overall payment, however, poses an important problem; Figure 6.4 presents that, the welfare for higher-income households is greatly improved (i.e., 20~40 percent increase), while the welfare for lower-income households is lowered by an approximately 5 percent decrease. The reason is that there is no tax progressivity in Case D.

On the other hand, Case E, where a progressive expenditure tax covers the total payment, shows that the individual welfare for all households improves by an about 10 percent increase. Hence, Case E, which assumes progressivity instead of proportionality, should be regarded as a more desirable policy reform than Case D in terms of equity. Of course, it is possible to change freely the degree of redistribution in Case E, by changing the degree of tax progressivity on expenditure, namely, two parameter values of α and β .

Household behavior is likely to be more distorted under the taxation on labor income than under the taxation on expenditure (or consumption), especially in the case of progressive taxation. This fact may be supported with the following two reasons.

First, when an expenditure tax is progressive and tax rates rise with age as in our analysis, it distorts the intertemporal consumption choice as shown in equation (6.6); rising marginal expenditure (or consumption) tax rates, like an interest income tax, raise the price of future consumption relative to current consumption. In this way, progressive expenditure taxation distorts individual age-profiles of consumption. Hence, we might expect this distortion to lead to a substantial reduction in savings and thus in the long-run capital stock. Progressive expenditure taxation, however, brings about more capital accumulation than progressive labor income taxation (see Chapter 3 for further details). Moreover, Auerbach and Kotlikoff (1987), where labor supply is assumed to be elastic, report that with the move from proportionality to progressivity, the capital stock declines less under the consumption tax than under the labor income tax, which continues to leave the intertemporal consumption decision undistorted.

Second, Auerbach and Kotlikoff (1987) also suggest that labor supply decreases more with the transfer from proportionality to progressivity under the labor income tax than under the consumption tax. This shortcoming for progressive labor income taxation does not come out in our model with an inelastic labor supply. In this sense, the taxation relatively has an advantage over progressive expenditure taxation in our analysis. The simulation analysis in Chapter 3, where the same model as this chapter is employed, nevertheless, reports that progressive expenditure taxation is superior to progressive labor income taxation in terms of both efficiency and equity. If labor supply were assumed to be elastic in our model, progressive expenditure taxation would bring forth even more favorable results than progressive labor income taxation. This fact should be stressed when we recommend progressive expenditure taxation as the most desirable tax regime.

6.4.2 Comments

The social welfare function represented by equation (6.7) evaluates the utility of the low-income class with great significance. The function can be regarded as a measure of the degree of equity, because the effects of the efficiency aspect on social welfare are relatively low. If we take pre-tax income as given, then it is obvious from the social welfare function used that progressive taxation leads to higher welfare, because it is maximized when after-tax income is equal for all income classes.

For instance, when comparing Cases C (partial integration and a proportional consumption tax) and D (perfect integration and a proportional expenditure tax), the capital-labor ratio (K/L) of 3.21 in Case C is much lower than 5.57 in Case D. But, the level of social welfare of -91773 in Case C is higher than -94118 in Case D. This is simply because there exists tax progressivity on labor income in Case C, while there is no progressivity in Case D, where a proportional expenditure tax covers the overall revenue.

6.5 Conclusions

This chapter has investigated whether or not the contribution to the public pension program in a pay-as-you-go system, which means a proportional labor income tax, should be substituted by (other) taxes such as a progressive labor income tax and a (progressive or proportional) consumption tax. The chapter has also examined what tax base is preferable as regards efficiency and equity in this integration case. To analyze this problem, we have adopted a simulation approach for an extended life-cycle general equilibrium model of overlapping generations with differences in the ability of labor supply, using the household expenditure survey data in Japan.

Our main proposal based on the simulation results includes two items. First, the integration of tax and public pension systems is desirable. In other words, the contribution to a public pension scheme should be replaced by general taxes such as a progressive labor income tax or a consumption tax. Second, the introduction of a

progressive expenditure tax is recommended as a tax base in the integration case. Hence, our proposal is to introduce a progressive expenditure tax with full integration in terms of efficiency and equity. As for structural reforms along the lines of the current Japanese system, we should promote the partial integration of tax and public pension systems as a transition process, substitute a consumption tax for the contribution, and implement a gradual shift towards perfect integration.

6.5.1 The current Japanese state and policy implications

When discussing policy implications based on the simulation results, it would be useful to show the fact that Japan has already partly introduced the integration of tax and social security systems. In other words, Japan is now in a transition process from a perfectly separate system to a completely integrated system. Let us take the example of the public pension system. The public pension system was drastically modified in 1985. The most significant reform was the introduction of a two-tier system on the benefit side: (1) a flat part (i.e., the basic pension) and (2) a proportional part (i.e., the part proportional to remuneration for each individual). The flat part currently pays about ¥65,000 per month to retired people. The amount is insufficient for each retired individual to survive, and thus lower than the level of a national minimum. The notion of the basic pension, however, comes certainly from and is consistent with the idea of a national minimum.

More importantly, general government tax revenue currently covers one-third of the flat part of public pension benefit in Japan. In other words, a part of tax revenue is already transferred to the social security system. It is possible to conclude that the social security system in Japan has been partly integrated with the tax system, because the share of one-third is considerable. Hence, our proposal is to take it further and to have a perfectly integrated system of tax and social security. This optimum system is consolidated by the introduction of a progressive expenditure tax (see Hatta (1996) for a discussion about the introduction of an expenditure tax in Japan).

6.5.2 Justification for our proposals

We point out four reasons why integration of the tax and social security systems is desirable.

First, the integration facilitates the introduction of the notion of a civil minimum (or national minimum) for all people, because the general government tax can cover a universal minimum level more efficiently and equitably. Several countries, such as Australia and New Zealand, adopt general taxes instead of contributions to cover social insurance payments. General taxes can cover such a minimum level with simplicity and at a lower cost.

Second, related to the first point, the integration can eliminate a typical argument of “who gained and who lost from the intergenerational or intragenerational aspect” under the social security system where contributions cover the cost. The argument has been one of the central popular issues and has been gaining momentum in Japan. If general taxes were used to pay for both public pension and medical care, it would be excluded that each individual contribution and benefit by social security can be calculated and compared in detail.

Third, a minimum subsistence guarantee by general taxes is consistent with the principle of social security, which intends to produce no desperately poor individuals. Such a goal can be achieved by the system that pays a minimum amount over the poverty level to all individuals. An individual, who desires a higher living standard or more sufficient security than a minimum level guaranteed by the government, can participate in such as enterprise pension, private pension, or private health insurance.

Fourth, the integration of tax and social security systems reduces considerably administration costs, because only one institution, namely, a tax bureau, collects revenue from the private sector. Coexistence of a tax bureau and a social insurance agency is costly regarding the administration cost of public revenues. A decrease in the administration cost would increase the total amount of payment on public pension and medical care.

Appendix 6.A

Section 6.2 describes the basic structure of households in the simulation model. This appendix presents those of firms and the government, and market equilibrium conditions.

Firm behavior

The production function is assumed to be of the constant elasticity of substitution (CES) form:

$$Y_t = Q \left[\varepsilon K_t^{1-\frac{1}{\sigma}} + (1-\varepsilon) L_t^{1-\frac{1}{\sigma}} \right]^{\frac{1}{1-\frac{1}{\sigma}}}, \quad (6.8)$$

where Y_t represents the total output, K_t the total capital, L_t the total labor supply measured by the efficiency units, Q a scaling constant, ε a parameter measuring the intensity of use of capital in production, and σ the elasticity of substitution between K_t and L_t . Using the property subject to a constant-returns-to-scale production function, the following equation can be obtained:

$$Y_t = rK_t + wL_t. \quad (6.9)$$

Government behavior

The government sector consists of a narrower government sector and a public pension sector. The narrower government sector collects taxes, and spends them on general government expenditure and a transfer to the pension sector. There is a transfer between these sectors. In the benchmark case A of 1995, the general tax revenue covers one-third of the basic pension (i.e., the flat part); and public pension contributions cover the rest of public pension payments, namely, remaining two-thirds of the basic pension in addition to all parts proportional to remuneration for each individual.

The budget constraint of a narrower government sector at time t is given by

$$T_t = G_t + \mu F_t, \quad (6.10)$$

where T_t is the total revenue from labor income, interest income, and consumption taxes (τ : the tax revenue per capita); G_t is the general government spending on goods and services, except for a transfer to the public pension sector (g : the general government expenditure per capita); F_t is the total amount of basic pension benefits (f : the amount of basic pension per capita); and μ is the ratio of the part covered by general tax revenues to F_t .

The budget constraint of a public pension sector at time t is given by

$$R_t = (1 - \mu)F_t + P_t, \quad (6.11)$$

where R_t is the total contributions to a public pension program, and P_t is the total benefits of the part proportional to remuneration. T_t , R_t , F_t , and P_t are defined respectively by

$$T_t = LX_t + \tau_r rAS_t + CX_t, \quad (6.12)$$

$$R_t = \tau_p wL_t, \quad (6.13)$$

$$F_t = N_t \sum_{s=ST}^{75} \left\{ p_s (1+n)^{-(s-1)} 275f \right\}, \quad (6.14)$$

$$P_t = N_t \sum_{s=ST}^{75} \left\{ p_s (1+n)^{-(s-1)} \sum_{i=1}^{275} \theta H^i \right\}, \quad (6.15)$$

where

$$T_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} 275\tau,$$

LX_t and CX_t are the tax revenues from labor income and consumption, respectively.

The revenues can be obtained by a simple summation of the 275 income classes with the same weight, because each income group accounts for the same proportion of population:

$$LX_t = N_t \sum_{s=1}^{RE} \left[p_s (1+n)^{-(s-1)} \sum_{i=1}^{275} \left\{ \alpha w x^i e_s + \frac{1}{2} \beta (w x^i e_s)^2 \right\} \right], \quad (6.16)$$

$$CX_t = N_t \sum_{s=1}^{75} \left[p_s (1+n)^{-(s-1)} \sum_{i=1}^{275} \left\{ \alpha C_s^i + \frac{1}{2} \beta (C_s^i)^2 \right\} \right]. \quad (6.17)$$

Similarly, aggregate assets supplied by households, AS_t , and aggregate consumption, AC_t , are derived from a simple summation of the 275 income classes,

respectively:

$$AS_t = N_t \sum_{s=1}^{75} \left\{ p_s (1+n)^{-(s-1)} \sum_{i=1}^{275} A_s^i \right\}, \quad (6.18)$$

$$AC_t = N_t \sum_{s=1}^{75} \left\{ p_s (1+n)^{-(s-1)} \sum_{i=1}^{275} C_s^i \right\}. \quad (6.19)$$

Market equilibrium

Finally, equilibrium conditions for the capital, labor, and goods markets are described.

1 Equilibrium condition for the capital market

$$AS_t = K_t. \quad (6.20)$$

2 Equilibrium condition for the labor market

$$L_t = N_t \sum_{s=1}^{RE} \left\{ p_s (1+n)^{-(s-1)} \sum_{i=1}^{275} x^i e_s \right\}. \quad (6.21)$$

3 Equilibrium condition for the goods market

$$Y_t = AC_t + (K_{t+1} - K_t) + G_t. \quad (6.22)$$

An iterative program is performed to obtain the equilibrium values of the above equations (see Appendix 3.B for the computation process).

Table 6.1 *Parameter values employed in simulation analysis*

	<i>Parameter values</i>
Intertemporal elasticity of substitution in utility	$\gamma = 0.2$
Elasticity of substitution in production	$\sigma = 0.6$
Weight parameter in production	$\varepsilon = 0.2$
Scale parameter in production	$Q = 1.0127$
Retirement age	$RE = 39$
Starting age for receiving public pension benefit	$ST = 40$
Amount of basic pension benefit per capita	$f = 0.19815$
Weight coefficient of proportional part in public pension benefit	$\theta = 0.32224$
Parameter for discounting the future	$\delta = -0.0231$
Growth rate of successive cohorts	$n = 0.01462$
New entrants at period t	$N_t = 15$

Table 6.2 *Estimation of the age-profile of earnings ability*

To estimate the age-profile of earnings ability, e_s , the following equation is used:

$$X = a + bN + cN^2,$$

where X denotes normalized annual labor income, i.e., x^i ($i = 1, 2, \dots, 275$), and N age of the head of each household.

<i>Variable</i>	<i>Estimated coefficient</i>	<i>Standard error</i>	<i>t-statistic</i>
a	-0.455200	0.546139	-0.83349
b	0.049149	0.025009	1.96525
c	-0.0003498	0.000280	-1.25106

Table 6.3 *Estimation of the parameters of tax progressivity on labor income*

To estimate the parameters of tax progressivity on labor income, α and β , in the benchmark case A, the following equation is employed:

$$T = a + b \frac{1}{2} X,$$

where T denotes the average tax rate on labor income and X normalized annual labor income, namely, x^i ($i = 1, 2, \dots, 275$).

<i>Variable</i>	<i>Estimated coefficient</i>	<i>Standard error</i>	<i>t-statistic</i>
<i>a</i>	-0.018767	0.004704	-3.9896
<i>b</i>	0.155266	0.008962	17.3246

Table 6.4 *Empirical results caused by different tax and public pension systems*

Case	A Benchmark	B Partial integration (Progressive labor income tax)	C Partial integration (Proportional consumption tax)	D Perfect integration (Proportional expenditure tax)	E Perfect integration (Progressive expenditure tax)
Tax revenue per capita (τ)	*0.0954	*0.1038	*0.1038	*0.2163	*0.2168
Tax rate on labor income (τ_w)	Progressive * $\begin{cases} \alpha = -0.0188 \\ \beta = 0.15527 \end{cases}$	Progressive * $\begin{cases} \alpha = -0.0188 \\ \beta = 0.17701 \end{cases}$	Progressive * $\begin{cases} \alpha = -0.0188 \\ \beta = 0.15527 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$
Tax rate on consumption (τ_c)	Proportional * $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	Proportional * $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	Proportional * $\begin{cases} \alpha = 0.06201 \\ \beta = 0 \end{cases}$	Proportional * $\begin{cases} \alpha = 0.31822 \\ \beta = 0 \end{cases}$	Progressive * $\begin{cases} \alpha = 0.15911 \\ \beta = 0.43283 \end{cases}$
Tax rate on interest income (τ_r)	0.2000	0.2000	0.2000	0.0000	0.0000
Contribution rate (τ_p)	0.1650	0.1527	0.1525	0.0000	0.0000
K/L	3.094	3.130	3.206	5.570	5.800
Y/L	1.198	1.199	1.202	1.262	1.265
K/Y	2.584	2.610	2.667	4.415	4.583
Interest rate (r)	0.0408	0.0401	0.0387	0.0167	0.0157
Wage rate (w)	1.0715	1.0737	1.0782	1.1688	1.1745
U1	-8127.22	-7771.36	-7920.46	-8424.53	-6039.86
U50	-474.58	-463.45	-467.46	-481.04	-415.64
U100	-248.83	-244.69	-245.41	-243.90	-223.83
U150	-140.79	-139.49	-138.97	-132.50	-129.20
U200	-90.88	-90.65	-89.74	-82.20	-84.43
U250	-39.85	-40.41	-39.37	-32.65	-37.54
U275	-10.68	-11.30	-10.55	-6.75	-9.81
Social welfare	-93350.91	-90976.88	-91773.24	-94117.74	-79595.29

Note: Asterisks (*) before numerical values indicate that the variables are exogenous.

Figure 6.1 *Distribution of households' annual labor income*

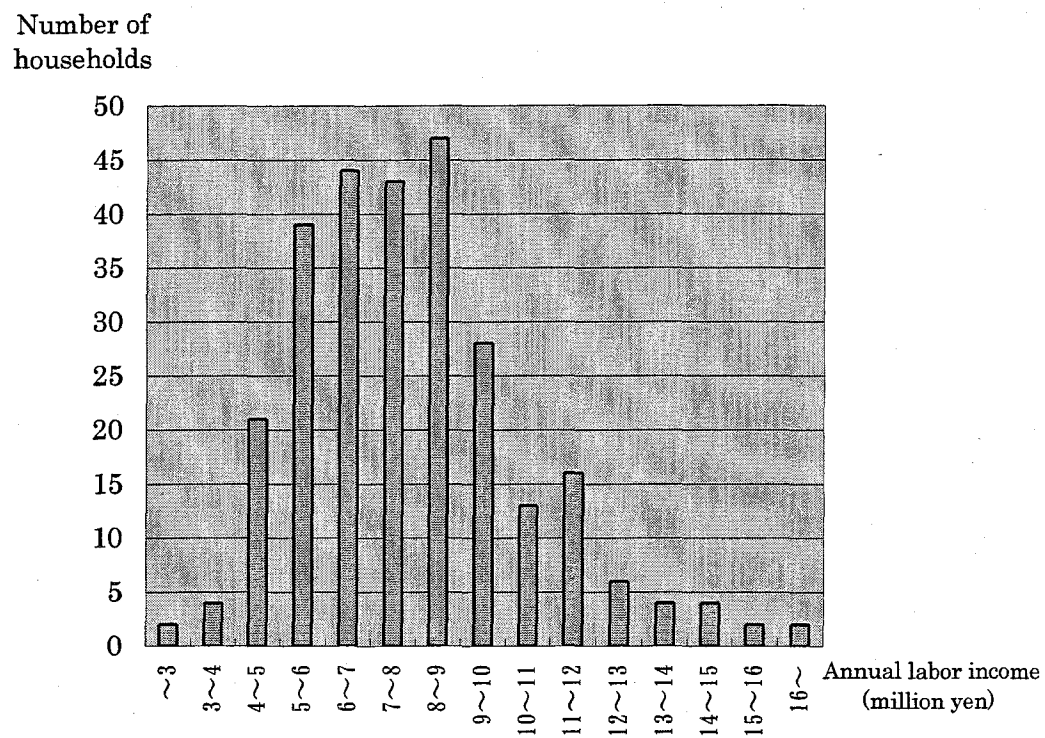


Figure 6.2 *Distribution of age-annual labor income*

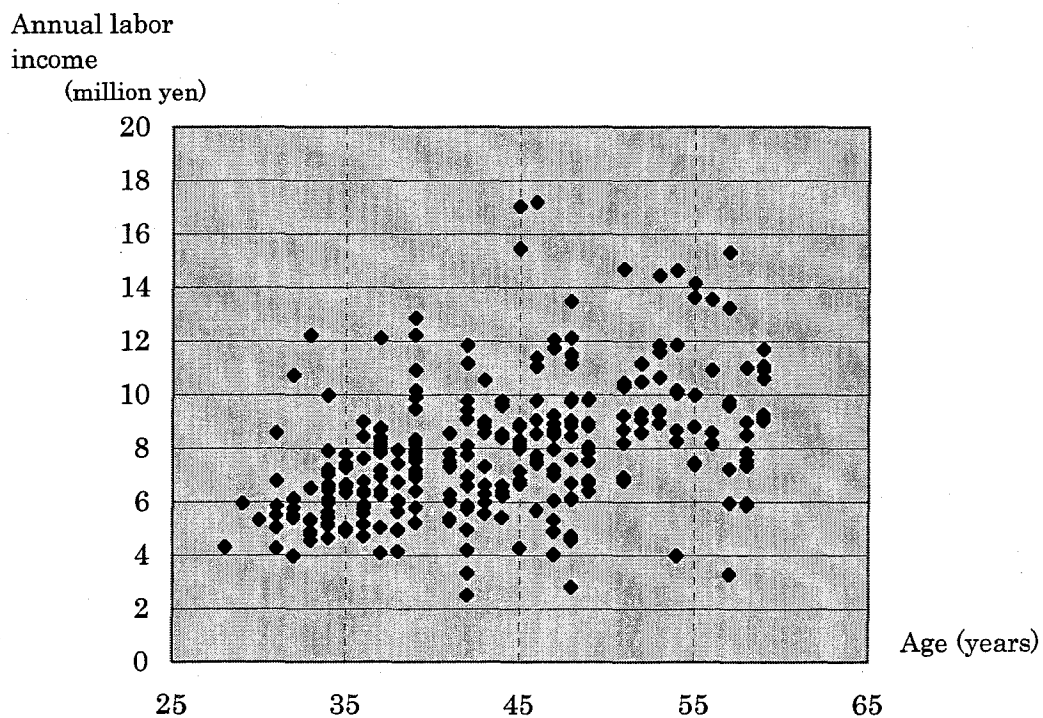


Figure 6.3 *Changes in welfare of 275 income class households*

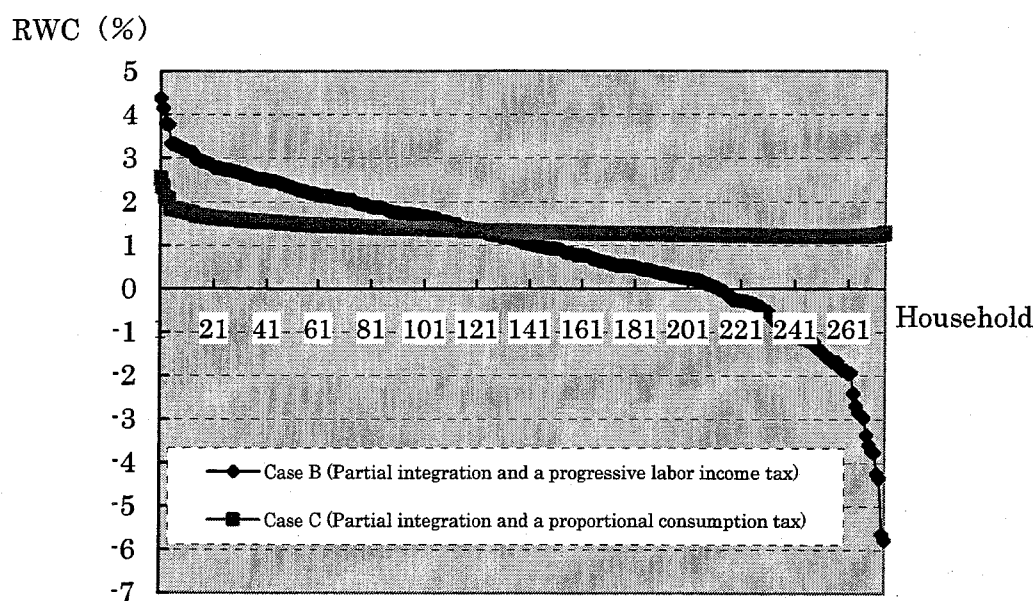
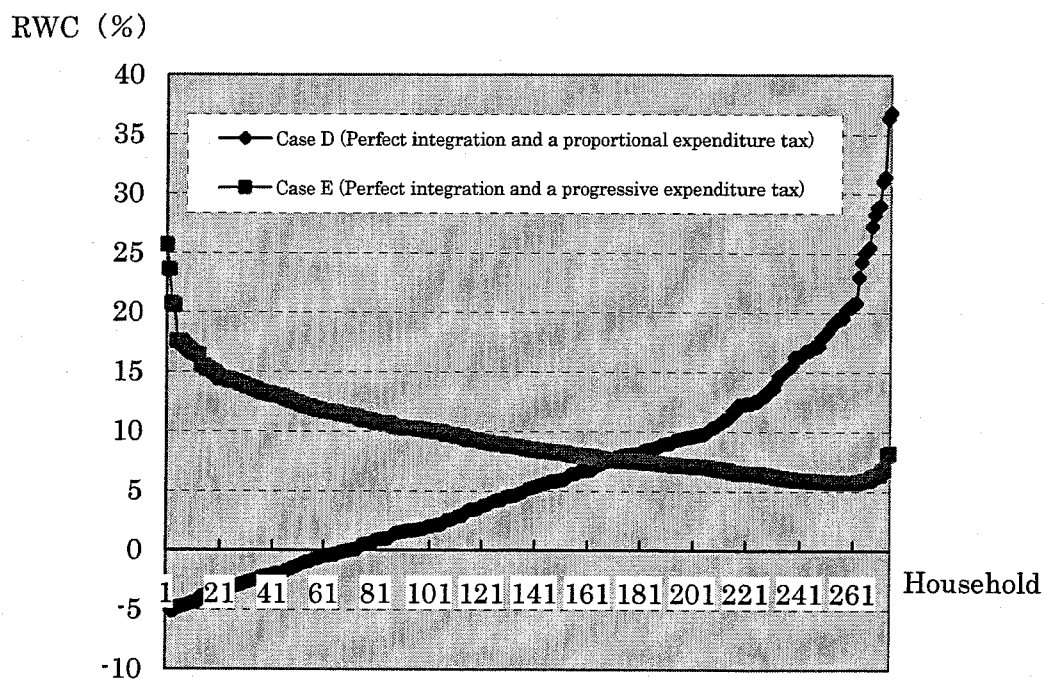


Figure 6.4 *Changes in welfare of 275 income class households*



7 A life-cycle general equilibrium simulation model with continuous income distribution

An application to an aging Japan*

Chapters 3 through 6 incorporated plural representative households with unequal incomes in each cohort, and addressed the problem of intragenerational redistribution. However, the changes in the variance of lifetime income distribution were not strictly dealt with. This chapter introduces numerous representative households with continuous income distribution into each cohort. This permits us to rigorously analyze changes in variance. When the log of earnings ability follows a normal distribution, a simulation can easily handle the diverse abilities of labor supply. This chapter examines the general equilibrium effects of changes in the variance of income distribution, on capital accumulation and social welfare.

7.1 Introduction

The rapid aging of the population is one of the most serious social and economic problems that Japan is facing. Tax reforms accommodating this drastic structural change have become an urgent policy issue. A life-cycle general equilibrium simulation model is suitable as a basic theoretical framework to examine the impact of

* An early version of this chapter was presented at the *1996 Annual Meeting of the Japan Association of Economics and Econometrics* at Osaka University. I am grateful for insightful comments and suggestions by Professors Toshiaki Tachibanaki, Naosumi Atoda, Yoshibumi Aso, Masahiro Hidaka, Kyoji Hashimoto, and from the seminar participants. I also acknowledge the financial support from The Zengin Foundation for Studies on Economics and Finance.

demographic changes on Japan's economy. There have been many papers that address the problems of an aging society by applying this kind of model. Nearly all, however, examine them only from the aspect of efficiency, or ignore the problem of intragenerational equity. For example, Auerbach *et al.* (1989) or Kato (1998) analyzed the effects of demographic transitions using this model. The papers published specify the behavior of a single representative individual, and thus it is impossible to deal with intragenerational income redistribution.

Since it is vital to take into account not only efficiency but also equity, plural representative households with unequal incomes should be incorporated. Fullerton and Rogers (1993) incorporate twelve lifetime income groups into a life-cycle model. However, that study could not analyze the effects of changes in the variance of income distribution, because it dealt with only twelve model-cases. To overcome this shortcoming, we incorporate a larger number of individuals, and construct a model with continuous income distribution.

This chapter has two purposes. One is to analyze how changes in the variance of income distribution affect various economic variables. The other is to show some useful guidelines for tax reforms in an aging Japan. We will investigate the effect of changes in the variance of income distribution on social welfare, by employing a simulation approach for an extended life-cycle general equilibrium model of overlapping generations.

There are two themes in this chapter. First, the disparity in lifetime earnings ability within a cohort and the relative position of each individual both correspond to the reality in Japan. Empirical data is employed to estimate the density function of labor endowment distribution. The introduction of income distribution to a social welfare function enables us to rigorously analyze the effects of tax reform on economic welfare. Second, we incorporate into the simulation model uncertainty regarding the length of an individual's life and unintended bequests. We consider the bequest motive based on the life-length uncertainty. The bequests, which were held as assets by

deceased households, are handed to surviving 50-year-old households. For a large number of different income classes, we take account of bequests. Inheritance is transferred within each income class with the same labor endowments. The different amounts of bequests among households reflect the different amounts of assets during their life cycle. This allows us to undertake analysis closer to the real world.

This chapter is organized as follows: Section 7.2 identifies the basic model employed in simulation analysis. Section 7.3 explains the method of simulation analysis and the assumptions adopted. Section 7.4 evaluates the simulation findings and discusses the policy implications. Section 7.5 summarizes and concludes the chapter.

7.2 Theoretical framework

We calibrate the simulation of the Japanese economy by employing population data estimated by the Institute of Population Problems of the Ministry of Health and Welfare in 1992. The model has 75 different overlapping generations. Three types of agents are considered: households, firms, and the government. The basic structure of each agent is first explained, and market equilibrium conditions are finally presented.

7.2.1 Household behavior

Each household has the same mortality rate and the same utility function. Unequal labor endowments, however, create different levels of income and consumption. The distribution of households' labor endowments is approximated by a lognormal distribution. The age-profile of earnings ability for each household is represented by xe_s . Its average value is equal to e_s , the profile of an average wageworker.¹ The weight factor x is distributed by the lognormal distribution whose density function is given by

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2\sigma^2}\left(\ln x + \frac{\sigma^2}{2}\right)^2\right] \quad (0 < x < \infty), \quad (7.1)$$

where the mean is equal to unity and the variance is $\exp(\sigma^2) - 1$.

Each household appears in the economy as a decision-making unit at the age of 21 and lives to a maximum of 95. Households face an age-dependent probability of death. Let $q_{j+1|j}$ be the conditional probability that a household of age $j + 20$ lives to age $j + 21$. Then the probability of a household of age 21 surviving until $s + 20$ can be expressed by

$$p_s = \prod_{j=1}^{s-1} q_{j+1|j}. \quad (7.2)$$

The probability $q_{j+1|j}$ is calculated from data estimated in 1992 by the Institute of Population Problems of the Ministry of Health and Welfare.

The utility of each household depends only on the level of consumption. There is no choice between leisure and labor supply. Each household works from age 21 to $RE + 20$, the retirement age. The labor supply is inelastic and after retirement is zero. Each household makes lifetime decisions at age 21 concerning the allocation of wealth between consumption and savings, to maximize expected lifetime utility. The utility function of a representative household with x -weighted labor endowments, whose form is assumed to be time-separable, is

$$U(x) = \frac{1}{1 - \frac{1}{\gamma}} \sum_{s=1}^{75} p_s (1 + \delta)^{-(s-1)} \{C_s(x)\}^{1 - \frac{1}{\gamma}}, \quad (7.3)$$

where $C_s(x)$ represents consumption (or expenditure) at age $s + 20$, δ the adjustment coefficient for discounting the future, and γ the intertemporal elasticity of substitution between consumption in different years.

The flow budget constraint equation of each household at age $s + 20$ is

$$A_{s+1}(x) = \{1 + r(1 - \tau_r)\}A_s(x) + \{1 - \tau_w(wxe_s) - \tau_p\}wxe_s + b_s(x) + a_s(x) - (1 + \tau_c)C_s(x), \quad (7.4)$$

where $A_s(x)$ represents the amount of assets held by the household at the beginning of age $s + 20$, r the interest rate, w the wage rate per efficiency unit of labor. wxe_s is the gross wage rate for each household. $b_s(x)$ is the amount of public pension

benefit, and $a_s(x)$ is the amount of bequest to be inherited at age $s + 20$. The tax rate on labor income is $\tau_w(wxe_s)$, on consumption is τ_c , and on interest income is τ_r . τ_p is the contribution rate to a public pension scheme.

The tax system consists of labor income, interest income, and consumption taxes. Labor income is taxed progressively: by choosing two parameters labeled α and β , we set the average tax rate $\tau_w(wxe_s)$ equal to $\alpha + \frac{1}{2}\beta(wxe_s)$ for all values of wxe_s . The corresponding marginal tax rate is $\alpha + \beta(wxe_s)$. Setting $\beta = 0$ amounts to proportional taxation. One may make the tax system more progressive, holding revenue constant, by increasing β and decreasing α simultaneously. The symbol $\tau_w(wxe_s)$ in equation (7.4) signifies that τ_w is a function of wxe_s . On the other hand, interest income and consumption are taxed proportionally: the tax rates on interest income and consumption are respectively τ_r and τ_c .

Variables related to the public pension program in a pay-as-you-go system are represented by

$$\begin{cases} b_s(x) = \theta H(x) & (s \geq ST) \\ b_s(x) = 0 & (s < ST) \end{cases}, \quad (7.5)$$

where the age at which each household starts to receive public pension benefits is $ST + 20$, the average annual remuneration is $H(x) \left(= \frac{1}{RE} \sum_{s=1}^{RE} wx_e_s \right)$, and the replacement ratio is θ . Thus, $b_s(x)$ closely reflects the difference in lifetime earnings ability among households.

There are unintended bequests caused by uncertainty regarding the length of life. The bequests, which were held as assets by deceased households, are handed to surviving 50-year-old households. Therefore $a_s(x)$ is positive if and only if $s = 30$, and otherwise zero. The inheritance is transferred within households with the same labor endowments, xe_s .² Let $BQ_t(x)$ be the sum of bequests inherited by 50-year-old households with x -weighted labor endowments at period t , and then $a_{30}(x)$ is defined by

$$a_{30}(x) = \frac{BQ_t(x)}{N_t p_{30} (1+n)^{-29}}, \quad (7.6)$$

where

$$BQ_t(x) = N_t \sum_{s=1}^{75} (p_s - p_{s+1}) (1+n)^{-(s-1)} A_{s+1}(x),$$

N_t is the number of new households entering the economy as decision-making units at period t , and n is the common growth rate of successive cohorts.

Let us consider the case in which each household maximizes its lifetime utility under a constraint. Each household maximizes equation (7.3) subject to equation (7.4). From the utility maximization problem, the equation expressing evolution of consumption over time for each household is characterized by

$$C_{s+1}(x) = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \right]^{\gamma} C_s(x). \quad (7.7)$$

From equation (7.7), optimal consumption behavior of all ages is derived, if initial consumption level $C_1(x)$ is specified (see Appendix 7.A for the detailed deduction). The amount of assets held by the household at each age is calculated from equation (7.4). The expected lifetime utility of each household is derived from equation (7.3).

The social welfare function SW , which takes into account the difference of ability in labor forces and continuous income distribution, is given by³

$$SW = \int_0^{\infty} f(x) U(x) dx. \quad (7.8)$$

Additionally, we consider ten income classes whose members are divided equally. The first and tenth income deciles correspond respectively to the “lowest and highest income classes.” The utility functions of these classes, W^l and W^h , are given by

$$\begin{cases} W^l = \int_0^{0.3575} f(x) U(x) dx \\ W^h = \int_{1.8527}^{\infty} f(x) U(x) dx \end{cases} \quad (7.9)$$

7.2.2 Firm behavior

The model has a single production sector that is assumed to behave competitively

using capital and labor, subject to a constant-returns-to-scale production function. Capital is homogeneous and non-depreciating, while labor differs only in its efficiency. All forms of labor are perfect substitutes. Households in different income classes or of different ages, however, supply different amounts of some standard measure per unit of labor input.

The production function is assumed to be of the constant elasticity of substitution form:

$$Y_t = B \left[\varepsilon K_t^{\frac{1-\rho}{\rho}} + (1-\varepsilon) L_t^{\frac{1-\rho}{\rho}} \right]^{\frac{\rho}{1-\rho}}, \quad (7.10)$$

where Y_t represents the total output, K_t the total capital, L_t the total labor supply measured by the efficiency units, B a scaling constant, ε a parameter measuring the intensity of use of capital in production, and ρ the elasticity of substitution between K_t and L_t . Using the property subject to a constant-returns-to-scale production function, we can obtain the following equation:

$$Y_t = rK_t + wL_t. \quad (7.11)$$

7.2.3 Government behavior

The government sector consists of a narrower government sector and a pension sector. The narrower government sector collects taxes and spends them on general governmental expenditure. There is no outstanding debt, and thus balanced budget policies are assumed. The budget constraint of the narrower government sector at time t is given by

$$G_t = T_t, \quad (7.12)$$

where G_t is government spending on goods and services in year t , and T_t is the overall tax revenue from labor income, interest income, and consumption.

The public pension system is assumed to be a simple pay-as-you-go style. The budget constraint of pension sector at time t is represented by

$$R_t = B_t, \quad (7.13)$$

where R_t is the total contributions to a public pension program, and B_t is the total pension benefits to generations of age $ST + 20$ and above.

Both of these sectors are financed independently and separately. No transfer is made between the sectors. G_t , T_t , R_t , and B_t are defined respectively by

$$G_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} g, \quad (7.14)$$

$$T_t = X_t + \tau_r r AS_t + \tau_c AC_t, \quad (7.15)$$

$$R_t = \tau_p w L_t, \quad (7.16)$$

$$B_t = N_t \sum_{s=ST}^{75} p_s (1+n)^{-(s-1)} \int_0^\infty f(x) b_s(x) dx, \quad (7.17)$$

where g is government expenditure per cohort and X_t is the tax revenue from labor income. Since labor income is progressively taxed, we get

$$X_t = N_t \left[w \alpha \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s + \frac{1}{2} w^2 \beta \exp(\sigma^2) \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s^2 \right]. \quad (7.18)$$

Aggregate assets supplied by households, AS_t , and aggregate consumption, AC_t , are represented by

$$AS_t = N_t [p_2 (1+n)^{-1} \int_0^\infty f(x) A_2(x) dx + p_3 (1+n)^{-2} \int_0^\infty f(x) A_3(x) dx + \dots + p_{75} (1+n)^{-74} \int_0^\infty f(x) A_{75}(x) dx], \quad (7.19)$$

$$AC_t = N_t [p_1 \int_0^\infty f(x) C_1(x) dx + p_2 (1+n)^{-1} \int_0^\infty f(x) C_2(x) dx + \dots + p_{75} (1+n)^{-74} \int_0^\infty f(x) C_{75}(x) dx]. \quad (7.20)$$

See Appendix 7.B for further details of the continuous distribution regarding lifetime earnings ability.

7.2.4 Market equilibrium

Finally, equilibrium conditions for the capital, labor, and goods markets are described.

1 Equilibrium condition for the capital market

Since aggregate assets supplied by households are equal to real capital, we get

$$AS_t = K_t. \quad (7.21)$$

2 Equilibrium condition for the labor market

Measured in efficiency units, since aggregate labor demand by firms is equal to aggregate labor supply by households, we obtain

$$L_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s. \quad (7.22)$$

3 Equilibrium condition for the goods market

As aggregate production is equal to the sum of consumption, investment, and government expenditures, we get

$$Y_t = AC_t + (K_{t+1} - K_t) + G_t. \quad (7.23)$$

An iterative program is performed to obtain the equilibrium values of the above equations.

7.3 Simulation analysis

7.3.1 Simulation method

The simulation model presented in the previous section is solved under a hypothesis of perfect foresight by households. Households correctly anticipate the interest, wage, and tax rates. If tax and public pension systems are determined, the model can be solved using the Gauss-Seidel method (see Appendix 7.C for the computation process).

We consider the current steady state of 1995.⁴ Tax revenue neutrality is assumed to ascertain the clear effects of tax reform. Our study holds that tax revenue is constant across all the simulation cases. The size of population and government expenditure per cohort (g) are exogenously given and constant across all cases. Thus, the total tax revenue, T_t , is exogenous and the same in all the simulations.

For the tax system, the tax rates on labor income ($\tau_w(wxe_s)$) and interest income (τ_r) are exogenously given, and thus on consumption (τ_c) is made endogenous. For the public pension system, the replacement ratio (θ) is exogenously given, and thus the contribution rate (τ_p) is made endogenous.

7.3.2 Simulation cases

Case A is the 1995 benchmark. Cases B and C investigate the influences of a change in

tax policies on after-tax income distribution. If in Case A, a proportional labor income tax replaces a progressive one, this case is then labeled Case B. If in Case A, a higher degree of tax progressivity on labor income is incorporated, this case is then labeled Case C. The tax revenue from labor income is the same across Cases A, B, and C.

The variance of lifetime income distribution is estimated based on actual data ($\sigma = 0.64$). This chapter considers two cases where the variance of income distribution is changed: in Case A-a the variance decreases ($\sigma = 0.5$), while in Case A-b the variance increases ($\sigma = 0.8$). Cases A-a and A-b evaluate the effects of an exogenous change in before-tax lifetime earnings ability on the economy. The limits of the lowest and highest income classes, represented by equation (7.9), are also changed in Cases A-a and A-b. In Case A-a, the upper limit of the lowest income class is 0.4650, and the lower limit of the highest income class is 1.6749. In Case A-b, the limits are 0.2608 and 2.0243, respectively.

The following five cases are considered:

1 Case A

This case is the 1995 benchmark; the tax system on labor income has a realistic progressiveness. Tax rates on interest income and consumption are set to 20 and 5 percent, respectively, which are the current Japanese rates.

2 Case B

In Case A, a proportional labor income tax replaces a progressive one, holding the tax revenue from labor income constant. Parameter β , which determines the degree of tax progressivity on labor income, is set to zero. The three tax regimes are all proportional.

3 Case C

In Case A, the degree of tax progressivity on labor income is raised, holding the tax revenue from labor income constant. Parameter α , which determines the degree of tax progressivity on labor income, is set to zero.

4 Case A-a

In Case A, the variance of income distribution decreases: the standard deviation (σ) is reduced to 0.5.

5 Case A-b

In Case A, the variance of income distribution increases: the standard deviation (σ) is raised to 0.8.

7.3.3 Specification of parameters

Table 7.2 presents the parameter values used in the simulation analysis. This chapter examines the implications of tax policies for an aging Japanese economy. Thus, we choose the parameter values realistic for the economy. In Case A (the benchmark), economic variables, such as the ratios of capital to income (K/Y) and capital to labor (K/L), are close to actual values of 1995. See Appendix 7.D for the calibration of the parameters that determine the distribution of weight x given to labor endowments and the degree of tax progressivity on labor income.

Survival probabilities (p_s) are calculated from the *Population Projections for Japan 1991-2090*. Our model makes no sex distinction, and so this study uses the male-female average values for 1995. The proportion of aged population (65 or above) to the total population (21 or above) in 1995 is 19.2 percent, based on the above estimates. The growth rate of successive cohorts (n) is adjusted so that the ratio in the simulation is the estimated value of 19.2 percent. Thus, n is set to 1.462 percent.

As for the public pension system, the retirement age is 60 ($RE = 40$) and the starting age for receiving public pension is 65 ($ST = 45$). The replacement ratio of pension payments (θ) is chosen so that the contribution rate equals the 1995 rate of 16.5 percent in employees' pension plans (*Kosei Nenkin*). Therefore, the replacement ratio (θ) is set to 63.5 percent of a standard annual remuneration.

7.4 Simulation results

7.4.1 Findings in the simulation results

Table 7.4 presents the simulation results. Through comparing Cases B and C, we investigate how the different degrees of tax progressivity on labor income influence the Japanese economy. Through comparing Cases A-a and A-b, we also examine how different variances in the within-cohort income distribution affect the economy. It should be noted that the impact on capital accumulation is regarded as an indicator of efficiency. Thus, the effects of different tax policies are evaluated in terms of capital formation and social welfare.

(1) Effect of the different degrees of tax progressivity on labor income

To investigate the effect of a rise in the tax progressivity on labor income, we consider the move from Case B (proportional tax) to C (progressive tax). The utility of the lowest income class ameliorates from -2.525 to -1.908, while for the highest income class it deteriorates from -0.00016 to -0.00019. Thus, a rise in the tax progressivity on labor income improves social welfare from -2.807 to -2.136. This suggests that the recent tendency in Japan to flat taxation may cause substantial damage to social welfare.

Two reasons can be considered. One is that through the change in a time path of taxation during an individual's life cycle, a rise in tax progressivity enhances the "capital increasing effect" (see Chapter 3 for the "capital increasing effect"). In Case B (proportional tax) the capital-labor ratio (K/L) is 2.784, while in Case C (progressive tax) it is 2.877. Thus, an increase in the ratio of K/L improves social welfare. The other is that the social welfare function represented by equation (7.8) places a substantial weight on the utility of the low-income class. This function is of a "Benthamite type," but depends mainly on the utility of the low-income class, as does a "Rawlsian type." Because of the property of the social welfare function adopted, the utility of the low-income class plays a significant role in the determination of social welfare.

To evaluate which of these reasons is more important, we undertook a sensitivity

analysis (see Appendix 7.E for further details). The results suggest that the latter (equity factor) dominates the former (efficiency factor). An increase in aggregate consumption improves social welfare, but its contribution is relatively low. The income redistribution between low and high-income classes substantially improves social welfare. The level of social welfare in our model depends mainly on the distribution of resources.

(2) Effect of the different variances in lifetime earnings ability

We first investigate the effects of a change in the variance of lifetime earnings ability on social welfare. The simulation results suggest that a decrease in the variance improves social welfare from -2.313 (Case A) to -0.478 (Case A-a), while an increase in the variance deteriorates social welfare to -18.560 (Case A-b). As the variance of lifetime earnings ability approaches zero, social welfare improves. The more equal the within-cohort income distribution, the higher the social welfare. The following two reasons are considered:

One is that social welfare depends mainly on the utility of the low-income class. A low variance of income distribution means few low-income households, which improves social welfare. On the other hand, a high variance signifies many low-income households, which deteriorates social welfare. The other is that the different variances in lifetime earnings ability generate different tax revenues from labor income. A high within-cohort inequality means the existence of many high-income households, whose tax rates are high under progressive taxation. In the case of a small variance (A-a) the tax revenue from labor income decreases to 18.0, while in the case of a large variance (A-b) it increases to 23.3. It should be noted that the tax rate on consumption is adjusted to keep the total tax revenue constant across the simulation cases. In Case A-a the tax rate on consumption rises, while in Case A-b it falls. The capital-labor ratio (K/L) in Case A-a is 2.903, while in Case A-b it is 2.747. As explained in Chapter 2, a consumption tax substantially stimulates capital formation.

Second, we examine the impacts of a change in the variance of lifetime earnings

ability on the utilities of the lowest and highest income classes. In the case of a small variance (A-a), the utility of the lowest income class is -0.361, while for the highest income class it is -0.00031. In the case of a large variance (A-b), the utilities are -17.979 and -0.00011, respectively. Thus, in Case A-b, the disparity between the lowest and highest income classes is substantial.

Finally, the influences of a change in the variance of lifetime earnings ability under proportional taxation are analyzed. In Case B (proportional taxation), the effects of different variances in income distribution are evaluated. The simulation results suggest that changes in variance have no influence on aggregate economic variables such as total consumption and total capital. These variables are the same as those in the case where there are many identical households in the economy represented by a single household. Thus, the simulation suggests, quantitatively, that only under progressive taxation do changes in variance in income distribution affect aggregate economic variables. In other words, under proportional taxation, changes in variance have no influence on aggregate variables. This is numerically verified in Appendix 7.B.

7.4.2 Comments

Two comments need to be noted in interpreting the simulation results.

First, the simulation results indicate that the higher the tax progressivity, the more the capital accumulation. This is because our model assumes an *inelastic* labor supply, and thus tax progressivity has no impact on labor supply. If the model incorporated a tax-induced disincentive effect, a high tax progressivity would not always bring forth favorable outcomes in terms of efficiency. Due to the assumption of an *inelastic* labor supply, an increase in progressiveness can decrease the dispersion of after-tax income distribution without reducing the labor supply. If labor supply is *elastic* in our model, this disincentive effect of progressive taxation will be harmful to social welfare.⁵

Second, this chapter incorporates many representative households and constructs

a model with continuous income distribution. Our study assumes a constant variance of earnings-ability distribution throughout an entire career. However, in reality, the disparity in income distribution gradually grows with age. Figure 3.4 presents the age-profiles of earnings ability based on educational backgrounds. This figure suggests that the difference in earnings ability within a cohort gradually increases with age. According to Ohtake and Saito (1998), consumption inequality within a fixed cohort starts to increase at the age of 40. We should bear in mind how simulation results would be different if the variance of income distribution gradually increases with age.⁶ In order to examine this situation, we undertook an additional simulation analysis (see Appendix 7.F for further details).

7.5 Conclusions

This chapter has examined the effect of changes in the variance of within-cohort after-tax income distribution on efficiency and equity in Japan, a society with an aging population. To analyze this problem, we employed a simulation approach for an extended life-cycle general equilibrium model of overlapping generations with continuous income distribution.

The simulation results suggest, quantitatively, that a decrease in variance of the within-cohort income distribution improves social welfare. A slight increase in tax progressivity on labor income substantially ameliorates social welfare. Therefore, the recent tendency in Japan, where tax progressivity has been reduced and flat taxation is approached, might cause serious damage to the social welfare of the population. The results also indicate that only under progressive taxation do changes in variance of income distribution affect aggregate economic variables.

Appendix 7.A

To consider the utility maximization problem over time for each household, namely the maximization of equation (7.3) subject to equation (7.4), let the Lagrange function be

$$L(x) = U(x) + \sum_{s=1}^{75} \lambda_s(x) \left[-A_{s+1}(x) + \{1+r(1-\tau_r)\}A_s(x) + \{1-\tau_w(wxe_s) - \tau_p\}wxe_s + b_s(x) + a_s(x) - (1+\tau_c)C_s(x) \right]$$

where $\lambda_s(x)$ represents the Lagrange multiplier for equation (7.4). The first-order conditions for $s = 1, 2, \dots, 75$ can be expressed by

$$\frac{\partial L(x)}{\partial C_s(x)} = p_s(1+\delta)^{-(s-1)} \{C_s\}^{\frac{1}{\gamma}}(x) - \lambda_s(x)(1+\tau_c) = 0, \quad (7.A)$$

$$\frac{\partial L(x)}{\partial A_{s+1}(x)} = -\lambda_s(x) + \lambda_{s+1}(x)\{1+r(1-\tau_r)\} = 0. \quad (7.B)$$

The combination of equations (7.A) and (7.B) yields the equation that determines the slope of the age-consumption profile over the life cycle:

$$C_{s+1}(x) = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \right]^\gamma C_s(x). \quad (7.7)$$

For a given $C_1(x)$, equation (7.7) solves the path for consumption. The transformation of equation (7.7) leads to the following expression:

$$C_s(x) = \left(\frac{p_s}{p_1} \right)^\gamma \left[\frac{1+r(1-\tau_r)}{1+\delta} \right]^{\gamma(s-1)} C_1(x). \quad (7.7)'$$

Integrating equation (7.4) and using the initial and terminal conditions

$A_1(x) = A_{76}(x) = 0$, caused by no intended bequests, yield the following equation:

$$\sum_{s=1}^{75} \{1+r(1-\tau_r)\}^{-(s-1)} (1+\tau_c)C_s(x) = \sum_{s=1}^{RE} \{1+r(1-\tau_r)\}^{-(s-1)} [1-\tau_w(wxe_s) - \tau_p]wxe_s + \sum_{s=ST}^{75} \{1+r(1-\tau_r)\}^{-(s-1)} b_s(x) + \{1+r(1-\tau_r)\}^{-29} a_{30}(x).$$

To derive $C_1(x)$, equation (7.7)' is substituted into this lifetime budget constraint.

Thus we can find an optimum solution for $C_1(x)$.

Appendix 7.B

We demonstrate the effects of changes in the variance of earnings ability distribution on economic variables, using a numerical demonstration. The probability density function represented by equation (7.1) leads to the following expressions:

Since x has a mean of unity ($0 < x < \infty$),

$$E(x) = \int_0^\infty f(x)x dx = 1, \quad (7.a)$$

and since x has a variance of $\exp(\sigma^2) - 1$,

$$V(x) = E\{[x - E(x)]^2\} = E(x^2) - 2E(x) + 1 = \int_0^\infty f(x)x^2 dx - 1 = \exp(\sigma^2) - 1, \\ \therefore \int_0^\infty f(x)x^2 dx = \exp(\sigma^2). \quad (7.b)$$

As explained in Appendix 7.A, initial consumption of the x -weighted household is represented by

$$C_1(x) = \frac{w \sum_{s=1}^{RE} R^{-(s-1)} [1 - \tau_w(wxe_s) - \tau_p] xe_s + \sum_{s=ST}^{75} R^{-(s-1)} b_s(x) + R^{-29} a_{30}(x)}{[1 + \tau_c\{C_s(x)\}] \sum_{s=1}^{75} R^{-(s-1)} \left(\frac{p_s}{p_1}\right)^y \left[\frac{R}{1+\delta}\right]^{r(s-1)}}, \quad (7.c)$$

where $R = 1 + r(1 - \tau_r)$.

Since the variance σ^2 affects aggregate economic variables through equation (7.b), we focus on the term x^2 . When labor income is progressively taxed (i.e., β is positive), the term x^2 arises from the term $\alpha e_s x + \frac{1}{2} \beta w e_s^2 x^2$, the product of $\tau_w(wxe_s)$ multiplied by xe_s (see equation (7.c)). If β is positive, $C_1(x)$ has the term x^2 . Thus, from equations (7.7) and (7.4), $C_s(x)$ and $A_{s+1}(x)$ ($s = 1, 2, \dots, 75$) also have the term. Under proportional taxation, namely, $\beta = 0$, both $C_s(x)$ and $A_{s+1}(x)$ ($s = 1, 2, \dots, 75$) have only the term x . In the absence of the term x^2 , the changes in variance of earnings-ability distribution have no effects on economic variables such as aggregate consumption AC_t or aggregate assets AS_t .

On the other hand, under progressive taxation, such relations no longer exist. β is positive, and thus the term x^2 appears. Aggregate economic variables include the term $\exp(\sigma^2)$ through equation (7.b). Hence, the changes in the variance (σ^2) affect aggregate variables. In this way, only under progressive taxation do changes in the within-cohort inequality influence the variables. Since the term $\exp(\sigma^2)$ does not exist under proportional taxation, this mechanism does not work. For instance, the tax revenue from labor income (TL_t) is derived from the following equations:

$$TL_t = N_t \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} \int_0^\infty f(x) \left\{ \alpha(wxe_s) + \frac{1}{2} \beta(wxe_s)^2 \right\} dx$$

$$\begin{aligned}
&= N_t w \alpha \left[e_1 p_1 \int_0^\infty f(x) x dx + \dots + e_{RE} p_{RE} (1+n)^{-(RE-1)} \int_0^\infty f(x) x dx \right] \\
&\quad + N_t \frac{1}{2} w^2 \beta \left[e_1^2 p_1 \int_0^\infty f(x) x^2 dx + \dots + e_{RE}^2 p_{RE} (1+n)^{-(RE-1)} \int_0^\infty f(x) x^2 dx \right] \\
&= N_t \left[w \alpha \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s + \frac{1}{2} w^2 \beta \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s^2 \int_0^\infty f(x) x^2 dx \right] \quad (\because \text{equation (7.a)}) \\
&= N_t \left[w \alpha \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s + \frac{1}{2} w^2 \beta \exp(\sigma^2) \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s^2 \right] \quad (\because \text{equation (7.b)})
\end{aligned}$$

Through the second term in this equation, the changes in variance affect aggregate variables, only when labor income is progressively taxed (i.e., when β is not zero).

See equation (7.18) for the tax revenue from consumption (TC_t). For other aggregate variables, the same remark also holds true.

Appendix 7.C

If tax and public pension systems are determined, the simulation model presented in Section 7.2 can be solved using the Gauss-Seidel method. The outline of a computation process is as follows.

Step 1

The interest rate r^0 , the wage rate w^0 , the bequest amount for each income class $\{a(x)\}^0$, the tax rate on interest income τ_r^0 , and the contribution rate to a public pension scheme τ_p^0 are chosen as initial values.

Step 2

Each household that maximizes the lifetime utility determines the time paths of consumption $\{C(x)\}^1$ and savings $\{S(x)\}^1$ for an entire life cycle, by taking the previous values and the tax rates on labor income $\tau_w(wxe_s)$ and consumption τ_c as given.

Step 3

Aggregate capital K^1 is obtained by summing the assets of each income class across cohorts, and by adding them $\{A(x)\}^1$ up within a cohort giving them a realistic weight.

The production equilibrium conditions, which are led by equation (7.10), provide a new interest rate r^1 and a new wage rate w^1 . The sum of bequests for each income class $\{BQ(x)\}^I$ is derived from the class's assets $\{A(x)\}^I$, which generates a new amount of bequest $\{a(x)\}^I$.

To balance the account of a narrower government sector, the tax rate on interest income changes to τ_r^1 . In a similar way to the balance of the account of a public pension sector, the contribution rate changes to τ_p^1 .

Step 4

Using r^1 , w^1 , $\{a(x)\}^I$, τ_r^1 , and τ_p^1 as new initial values, we return to Step 1. This method is iterated until we get equilibrium, or stable variables.

Appendix 7.D

Table 7.3 presents data obtained by adding two sources: data for income tax collected at the tax office; and data for self-assessed income tax. The data is based on the *Statistical Year Dissertation of National Taxes (Kokuzeicho Tokei-Nenposho) 1993*. We explain the method of assigning each weight to labor endowments, the degree of tax progressivity on labor income, and the variance of income distribution using this data.

We first explain how each weight x to lifetime earnings ability is assigned. The distribution of labor endowments is estimated from the data. The weight x is defined as the ratio of annual income of each household to the total average annual income (which is approximately 4.71 million yen). The weight x theoretically takes values between zero and ∞ in the model. However, our simulation assumes the value to be between zero and 4.8 (the range covers 99.7 percent of all households) for the reason that follows. For the high-income class whose weight x is very high, the tax rate on labor income is very high. Thus, disposable income is too low, compared with the amount of public pension benefit after retirement. Such a household borrows excessively while young, which leads to unreal consumption-savings behavior.

Second, the method of assigning the degree of tax progressivity on labor income is

described. The estimation is undertaken using the ordinary least squares (OLS) method. The parameters, α and β , which determine the degree of tax progressivity, should have been estimated using the tax rate on *labor income* as a dependent (explained) variable and $\frac{1}{2}wx\bar{e}$ as an independent (explanatory) variable. (Here, \bar{e} represents the average of e_s . \bar{e} is the value that takes account of the growth rate of successive cohorts and the survival probabilities.) However, adequate data for this estimation is not presently available in Japan.

As a second best means, the parameters, α and β , are estimated in the order that follows. First, the parameter of the proportional part, β , is estimated by applying the OLS method, using the average tax rate on *income* as a dependent variable and $\frac{1}{2}wx\bar{e}$ as an independent variable. Thus, β is estimated to be 0.0089. Next, given this value of β and the tax rate of 20 percent on interest income, a simulation is performed. The parameter of the constant part, α , is chosen so that the tax rate on consumption is 5 percent and the overall average tax rate on income is 8.15 percent (as shown in Table 7.3). Through this adjustment process, α is modified to be a plausible value from 0.0167, the firstly estimated value, to 0.0201.

Finally, the method of assigning the variance in the lifetime earnings-ability distribution is described. The standard deviation σ in the density function represented by equation (7.1) is estimated using the OLS method. It is obtained by minimizing the sum of squared differences between the observed and predicted probabilities:

$$\sum_{i=1}^{12} [\bar{p}_i - p_i(\sigma)]^2,$$

where i ($=1,2,\dots,12$) represents a bracket of each income class, \bar{p}_i is the number of observations in the i -th interval when the total number of people is normalized to unity, and $p_i(\sigma)$ is the theoretical probability of people in the same interval. Supposing that σ is the parameter of the theoretical distribution specified, then $p_i(\sigma)$ is defined by

$$p_i(\sigma) = \int_{x_{i-1}}^{x_i} f(x; \sigma) dx,$$

where x_i denotes the upper end of the bracket of the income class i as shown in Table 7.3, and $f(x; \sigma)$ is the density function. Thus the estimated value of σ is 0.642 (for reference, the estimated value in Atoda *et al.* (1988) is 0.659).

It should be noted that this estimated value of the standard deviation is based on cross-section data. The data includes all age groups, namely, young, middle, and old. Hence, this value concerns income distribution not of people who belong to the same cohort, but of all people who exist in the economy at a point in time (1993). The value of the standard deviation in *lifetime* income distribution is necessary in the model. We should have employed so-called panel data, which traces people who belong to the same cohort for a long period. However, this kind of data is not presently available in Japan, and thus the cross-section data was used as a second best source.

Appendix 7.E

Our simulation result suggests that social welfare improves when the tax progressivity on labor income is high. Two reasons are considered: one is the “capital-increasing effect” that is explained in Chapter 3; the other is that our social welfare function places a substantial weight on the utility of the low-income class. In order to evaluate in a quantitative way which of these effects is more significant, we undertook a sensitivity analysis for exogenous changes of labor supply. Table 7.5 presents the simulation results. In the move from Case A (progressive taxation) to Case B (proportional taxation), labor supply is constant (306.2) in our model. To allow for the incentive effect on labor supply by the shift from progressivity to proportionality, we raise labor supply exogenously.

First, aggregate consumption is 279.6 in Case A, and it is 278.3 in Case B. In order to make up this gap, an increase in labor supply is necessary in Case B. When labor supply exogenously increases to 312.2 (this case is labeled Case B-1), aggregate consumption is 279.6 that is the same as in Case A. In other words, if labor supply

increases by 1.96 percent in the transfer to proportional taxation, Cases B-1 and A have the same level of aggregate consumption. In Case B-1, social welfare slightly improves (from -2.807) to -2.758. This result may suggest that the main difference in social welfare between Cases A and B is related to the property of the social welfare function.

Second, social welfare is -2.313 in Case A, and it is -2.807 in Case B. In order to cover this disparity, an increase in labor supply is required in Case B. When labor supply exogenously increases to 386.9 (this case is labeled Case B-2), social welfare is -2.313 that is the same as in Case A. In other words, if labor supply increases by 26.4 percent in the transfer to proportional taxation, Cases B-2 and A have the same level of social welfare. Without this substantial increase in labor supply, the shift to flat taxation would deteriorate social welfare.

Appendix 7.F

Although our model assumes a constant variance in within-cohort distribution of earnings ability throughout an entire lifetime, it, in reality, increases gradually with age. If the increasing variance with age were introduced into a model, how the simulation results would be different? In this appendix, we incorporate an increase in within-cohort inequality with age. The simulation analysis was implemented using a model with two representative households corresponding to the low and high income classes. For example, in Creedy (1992) the growing variance of within-cohort earnings distribution is approximated by an increasing linear function of age.

The weights given to the average age-profile of earnings ability, e_s , for the low and high income classes are represented respectively by

$$x^l = 1 - \mu s \quad \text{and} \quad x^h = 1 + \mu s,$$

where μ represents the variance parameter. $x^l e_s$ and $x^h e_s$ are the age-profiles of earnings ability for the low and high income classes, respectively. In the simulation, μ is set to 0.0125. x^l and x^h are respectively 0.9875 and 1.0125 at the initial

point $s = 1$. The gap widens gradually with age ($x^l = 0.5$ and $x^h = 1.5$ at the terminal point $s = 40$). This disparity is estimated by the age-profiles of earnings ability based on educational backgrounds in Figure 3.4. Thus, for the low-income class the age-profile of earnings ability has a gentle slope, while for the high-income class it is steeper. We undertook a simulation analysis using the model revised above.

The shape of the age-profile of earnings ability differs between the low and high income classes. On the other hand, the shape of the age-profile of consumption is the same between the two classes, as shown in equation (7.7). Only the level of consumption differs between them. Figure 7.1 suggests that the shape of the age-profile of assets differs between the low and high income classes. The low-income class borrows less during the young period, which reflects the gentle slope of the age-profile of earnings ability. A typical example for this case is blue-collar workers such as junior high school graduates in a small or medium-sized enterprise. The high-income class borrows more during youth, which reflects the sharp slope of the age-profile. A typical example for this is white-collar university graduates in a large firm.

Table 7.1 *Estimation of the age-profile of earnings ability*

a_0	a_1	a_2
-2.12653 (-8.09994)	0.207861 (14.8385)	-0.00223731 (-13.4930)

$$\begin{cases} S.E. = 0.136 \\ R^2 = 0.967 \end{cases}$$

Table 7.2 *Parameter values used in simulation analysis*

	Parameter values
Adjustment coefficient for discounting the future	$\delta = -0.01627$
Intertemporal elasticity of substitution	$\gamma = 0.2$
Elasticity of substitution in production	$\rho = 0.6$
Weight parameter in production	$\varepsilon = 0.2$
Scale parameter in production	$B = 0.942$
Government expenditure per generation	$g = 0.697526$
Growth rate of successive cohorts	$n = 0.01462$
Replacement ratio in public pension	$\theta = 0.63466$

Table 7.3 *Income distribution and taxes on households*

i	Income class (million yen)	Number of persons (,000)	Ratio (\bar{P}_i)	Total amount of income (billion yen)	Average annual income (million yen)	\bar{x} (Average)	x_i (Upper end)	Total amount of taxes (billion yen)	Average tax rate on income (%)
1	~1	3,543	0.0692	2,685	0.76	0.16	0.212	29	1.08
2	1~2	5,977	0.1167	9,252	1.55	0.33	0.424	249	2.69
3	2~3	8,990	0.1756	22,766	2.53	0.54	0.636	840	3.69
4	3~4	8,899	0.1738	31,064	3.49	0.74	0.849	1,264	4.07
5	4~5	7,052	0.1377	31,591	4.48	0.95	1.061	1,342	4.25
6	5~6	5,100	0.0996	28,003	5.49	1.16	1.273	1,299	4.64
7	6~7	3,459	0.0676	22,399	6.48	1.37	1.485	1,180	5.27
8	7~8	2,404	0.0470	17,933	7.46	1.58	1.697	1,146	6.39
9	8~10	2,584	0.0505	22,964	8.89	1.89	2.121	1,907	8.30
10	10~12	1,285	0.0251	14,099	10.97	2.33	2.546	1,604	11.38
11	12~15	904	0.0177	12,067	13.35	2.83	3.182	1,867	15.47
12	15~20	566	0.0111	9,684	17.11	3.63	4.243	2,029	20.95
13	20~	435	0.0085	16,835	38.70	8.21		4,903	29.12
	Total (average)	51,198	1	241,342	4.71	1		19,659	8.15

(Source: *Statistical Year Dissertation of National Taxes 1993*, National Tax Administration Agency, Japan (1995).)

Table 7.4 Empirical results caused by different degrees of tax progressivity on labor income and different variances in income distribution

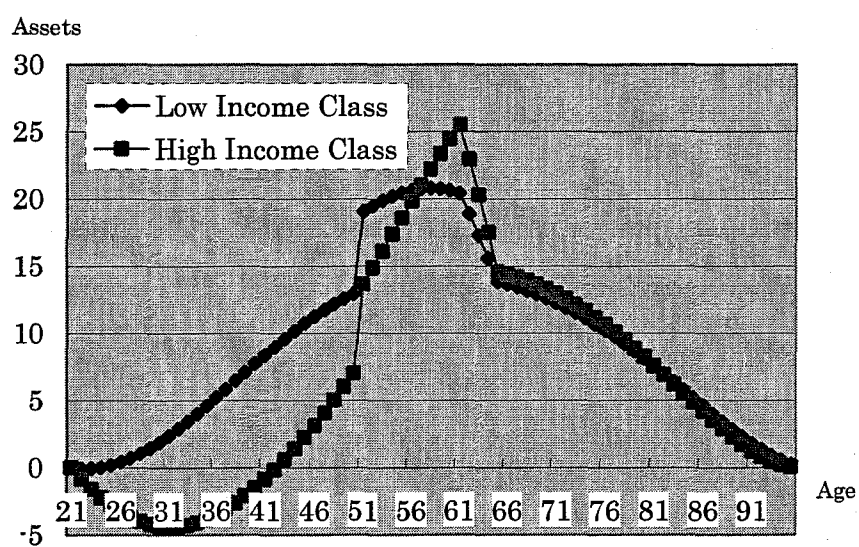
Case	A	B	C	A-a	A-b
Standard deviation (σ)	*0.64	*0.64	*0.64	*0.5	*0.8
Tax rate on labor income ($\tau_w(wxe_s)$)	<i>Progressive</i> * $\begin{cases} \alpha = 0.0201 \\ \beta = 0.0089 \end{cases}$	<i>Proportional</i> * $\begin{cases} \alpha = 0.0668 \\ \beta = 0 \end{cases}$	<i>Progressive</i> * $\begin{cases} \alpha = 0 \\ \beta = 0.0127 \end{cases}$	<i>Progressive</i> * $\begin{cases} \alpha = 0.0201 \\ \beta = 0.0089 \end{cases}$	<i>Progressive</i> * $\begin{cases} \alpha = 0.0201 \\ \beta = 0.0089 \end{cases}$
Tax rate on interest income (τ_r)	*0.2000	*0.2000	*0.2000	*0.2000	*0.2000
Tax rate on consumption ($\tau_c\{C_s(x)\}$)	0.0500	0.0499	0.0500	0.0565	0.0392
Capital-labor ratio (K/L)	2.849	2.784	2.877	2.903	2.747
Income-labor ratio (Y/L)	1.104	1.101	1.105	1.106	1.100
Capital-income ratio (K/Y)	2.580	2.528	2.603	2.624	2.498
Interest rate (r)	0.0429	0.0444	0.0423	0.0417	0.0452
Wage rate (w)	0.9820	0.9778	0.9838	0.9854	0.9754
Total capital (K_t)	872.4	852.5	880.9	888.8	841.2
Social welfare (SW)	-2.313	-2.807	-2.136	-0.478	-18.560
Lowest income class utility (W^l)	-2.071	-2.525	-1.908	-0.361	-17.979
Highest income class utility (W^h)	-0.00018	-0.00016	-0.00019	-0.00031	-0.00011
Aggregate consumption (AC_t)	279.6	278.3	280.2	283.6	269.2
Tax revenue from labor income (TL_t)	20.0	20.0	20.0	18.0	23.3

Note: The asterisks (*) before the tax rate indicate that the variable is exogenous.

Table 7.5 *Simulation results for exogenous changes in labor supply*

<i>Case</i>	Labor supply	Total consumption	Social welfare	K/L	Interest rate	Wage rate	Tax rate on consumption
B-1	312.2	279.6	-2.758	2.768	0.0447	0.9768	0.0492
B-2	386.9	293.3	-2.313	2.555	0.0504	0.9618	0.0403

Figure 7.1 *Age-profiles of assets under a progressive labor income tax*



8 Within-cohort inequality and tax reforms in an aging Japan*

This chapter takes account of within-cohort inequality that increases in a transition to an aging society. The simulation model employed in this chapter is basically the same as that in Chapter 7. This chapter demonstrates the general equilibrium effects of an increasing variance in the lifetime income distribution with an aging Japanese population. It also studies the macroeconomic and welfare effects of introducing progressive expenditure taxation in this situation.

8.1 Introduction

Ohtake and Saito (1998) report that younger generations have recently tended to face a high consumption inequality from the start of their life cycle in Japan, because within-cohort inequality may be transmitted from older generations to younger ones through intergenerational transfers. We will focus on this fact, and investigate the effects of a rise of within-cohort inequality on the macroeconomic and welfare effects in a situation of the rapid aging of the Japanese population.¹ Since a life-cycle general equilibrium model is suitable as a basic theoretical framework to examine the impacts

* An earlier version of this chapter was presented at the *International Forum on Tax Reforms in Japan* organized by Economic and Social Research Institute (ESRI) at the Cabinet Office (Government of Japan) in September 2002. I am grateful for insightful comments and suggestions by Professors Alan J. Auerbach (University of California, Berkeley), Laurence J. Kotlikoff (Boston University), David E. Weinstein (Columbia University), Anil Kashyap (University of Chicago), Koichi Hamada (Yale University), Toshihiro Ihori (University of Tokyo), and Toshiyuki Uemura (Toyo University). I also acknowledge the financial support from the Ministry of Education, Culture, Sports, Science and Technology in Japan (the Grant-in-Aid for Encouragement of Young Scientists No.13730064).

of demographic changes on various social and economic variables, the model is employed to analyze the above problem.

The purpose of this chapter is to establish guidelines for structural tax reforms, in an aging Japan where within-cohort inequality of consumption would increase. The chapter, in a quantitative way, will explore the effects of a progressive expenditure tax on capital accumulation as well as intragenerational income redistribution.

This chapter makes a significant contribution to the literature by incorporating the *continuous* distribution of income or consumption in each cohort. When the log of labor income follows a normal distribution, a simulation can easily deal with diverse abilities of the labor supply. This novel idea will bring a substantial improvement upon not only the existing studies that have assumed a representative agent but also those with several representative individuals.

Since the *variance* of the distribution is explicitly incorporated, this approach can handle the effects of changes in the dispersion on efficiency and equity. We introduce the intragenerational disparity in labor endowments and the relative position of each individual corresponding to the reality in Japan. This is achieved by the estimation of the density function of the earnings-ability distribution using empirical data. The introduction of the within-cohort continuous distribution to the social welfare function permits us to analyze the effects of tax reforms on overall economic welfare in a model with a greater similarity to the real world.

This chapter is organized as follows: Section 8.2 identifies the basic model employed in simulation analysis. Section 8.3 explains the method of simulation analysis and the assumptions adopted. Section 8.4 evaluates the simulation findings and discusses their interpretation. Section 8.5 summarizes and concludes the chapter.

8.2 Theoretical framework

We calibrate the simulation of the Japanese economy by employing population data estimated by the Institute of Population Problems of the Ministry of Health and Welfare

in 1997. The model has 75 different overlapping generations. Three types of agents are considered: households, firms, and the government. Since the basic model in this chapter is the same as in Chapter 7, see 7.2 *Theoretical framework* for detailed explanation. The basic structure of households is as follows.

8.2.1 Household behavior

The distribution of households' labor endowments is approximated by a lognormal distribution. The age-profile of earnings ability for each household is represented by xe_s . Its average value is equal to e_s , the profile of an average waged worker.² The weight factor x is distributed by the lognormal distribution whose density function is given by

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2\sigma^2}\left(\ln x + \frac{\sigma^2}{2}\right)^2\right] \quad (0 < x < \infty), \quad (8.1)$$

where the mean is equal to unity and the variance is $\exp(\sigma^2) - 1$. Let $q_{j+1|j}$ be the conditional probability that a household of age $j + 20$ lives to age $j + 21$. Then the probability of a household of age 21 surviving until $s + 20$ can be expressed by

$$p_s = \prod_{j=1}^{s-1} q_{j+1|j}. \quad (8.2)$$

The probability $q_{j+1|j}$ is calculated from data estimated in 1997 by the Institute of Population Problems of the Ministry of Health and Welfare.

The utility function of a representative household with x -weighted labor endowments, whose form is assumed to be time-separable, is

$$U(x) = \frac{1}{1 - \frac{1}{\gamma}} \sum_{s=1}^{75} p_s (1 + \delta)^{-(s-1)} \{C_s(x)\}^{1 - \frac{1}{\gamma}}, \quad (8.3)$$

where $C_s(x)$ represents consumption (or expenditure) at age $s + 20$, δ the adjustment coefficient for discounting the future, and γ the intertemporal elasticity of substitution on consumption.

The flow budget constraint equation of each household at age $s + 20$ is

$$A_{s+1}(x) = \{1 + r(1 - \tau_r)\}A_s(x) + \{1 - \tau_w(wxe_s) - \tau_p\}wxe_s + b_s(x) + a_s(x) - [1 + \tau_c\{C_s(x)\}]C_s(x) \quad (8.4)$$

where $A_s(x)$ represents the amount of assets held by the household at the beginning of age $s + 20$, r the interest rate, w the wage rate per efficiency unit of labor. wxe_s is regarded as the gross wage rate for the household. $b_s(x)$ is the amount of public pension benefit, and $a_s(x)$ is the amount of bequest to be inherited at age $s + 20$. $\tau_w(wxe_s)$ is the tax rate on labor income, $\tau_c\{C_s(x)\}$ that on consumption, τ_r that on interest income, and τ_p is the contribution rate to a public pension program.

Progressive taxation is adopted for the gross wage rate or the level of expenditure on an annual basis. The symbols $\tau_w(wxe_s)$ and $\tau_c\{C_s(x)\}$ in equation (8.4) mean that τ_w and τ_c are respectively functions of wxe_s and $C_s(x)$. Interest income is proportionally taxed. Variables related to the public pension system are represented by

$$\begin{cases} b_s(x) = \theta H(x) & (s \geq ST) \\ b_s(x) = 0 & (s < ST) \end{cases} \quad (8.5)$$

where the age at which each household starts to receive public pension benefits is

$ST + 20$, the average annual remuneration is $H(x) \left(= \frac{1}{RE} \sum_{s=1}^{RE} wxe_s \right)$, and the

replacement ratio is θ .

Let $BQ_t(x)$ be the sum of bequests inherited by 50-year-old households with x -weighted labor endowments at period t , and then $a_{30}(x)$ is defined by

$$a_{30}(x) = \frac{BQ_t(x)}{N_t p_{30} (1+n)^{-29}}, \quad (8.6)$$

where

$$BQ_t(x) = N_t \sum_{s=1}^{75} (p_s - p_{s+1})(1+n)^{-(s-1)} A_{s+1}(x),$$

N_t is the number of new households entering the economy as decision-making units at period t , and n is the common growth rate of successive cohorts.

Let us consider the case in which each household maximizes its lifetime utility

under a constraint. Each household maximizes equation (8.3) subject to equation (8.4) (see Appendix 8.A). From the utility maximization problem for each household, the equation expressing evolution of consumption over time is characterized by

$$C_{s+1}(x) = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1+r(1-\tau_r)}{1+\delta} \right\} \left(\frac{1+\bar{\tau}_c\{C_s(x)\}}{1+\tau_c\{C_{s+1}(x)\}} \right) \right]^\gamma C_s(x). \quad (8.7)$$

If initial consumption level, $C_1(x)$, is specified, optimal consumption behavior of all ages is derived from equation (8.7). The amount of assets held by the household at each age is calculated from equation (8.4). The expected lifetime utility of the household is obtained from equation (8.3).

The social welfare function, SW , which takes account of the difference of earnings ability and thus the resulting distribution of consumption, is given by

$$SW = \int_0^\infty f(x)U(x)dx. \quad (8.8)$$

This function is derived from a summation of the expected lifetime utilities at age 21 for all households within a cohort.

As for the basic structure of firms, a single production sector is assumed to behave competitively using capital and labor, subject to a constant returns-to-scale production function. See Appendix 8.B for those of firms and the government, and market equilibrium conditions.

8.3 Simulation analysis

8.3.1 Method of simulation

The parameter values, α and β , which denote tax progressivity on labor income or consumption (i.e., expenditure), are exogenously given. Thus, tax revenue neutrality makes the tax rate on interest income (τ_r) endogenous. As for the public pension system, the replacement ratio (θ) is exogenously given. Therefore, the contribution rate (τ_p) is made endogenous.

8.3.2 Simulations in various cases

We consider two demographic regimes, namely, the 2000 current steady state and the 2025 aged steady state. Case A is the current benchmark of 2000. Case B is the benchmark of an aged Japan projected for 2025. Cases A and B differ in population structure. Different survival probabilities (p_s) and different growth rates of successive cohorts (n) create different age structures of the population between the two demographic regimes (see Table 8.1 for the parameter values that characterize the two steady states). In an aged steady state, Japan faces a decline in the proportion of working population, with a subsequent decrease in aggregate output (Y_t); hence, it raises the ratio of the total tax revenue (T_t) to aggregate output (Y_t), and thus leads to a substantial increase in tax burden in an aging society. Under revenue neutrality, a consumption tax covers this extra tax burden caused by the transition from the current to the aged steady states.³

We will focus mainly on the aged steady-state simulations with the age structure projected for 2025, because we are interested in how tax reforms will affect the Japanese economy in the future. We will investigate the general equilibrium effects of intragenerational inequality (see Appendix 7.B for the effects of changes in the inequality on the economy). The 'Case-B' simulations have the same value of variance in within-cohort lifetime income distribution as that in the current benchmark case A (i.e., $\sigma = 0.635$). The 'Case-C' and 'Case-D' simulations have larger variances: the standard deviation, σ , is expanded to 0.65 and 0.67, respectively.⁴ Under progressive taxation, a rise in the variance increases the amount of tax revenue. In Cases C and D, the increased tax revenue from labor income is offset by a decrease in the tax rate on consumption under revenue neutrality.

The following seven simulation cases are now considered (see Tables 8.2 and 8.3 for the simulation cases and empirical results).

1 Case A (benchmark of the 2000 current state)

The standard deviation of within-cohort distribution of earnings ability is set to an estimated value of 0.635. The tax system on labor income has a realistic progressiveness (see Appendix 8.C for the assignment of tax-progressivity parameters, α and β , and for the estimation of the standard deviation, σ). Tax rates on consumption and interest income are 5 and 20 percent, respectively.

2 Case B (benchmark of the 2025 aged state)

The standard deviation of the distribution is the same as Case A. The degree of tax progressivity on labor income and the tax rate on interest income are the same as those in Case A. The extra tax burden, caused by a transition to an aged society, is covered by a consumption tax.

3 Cases C and D (large variance cases)

In Case B, the standard deviation is increased to 0.65 and 0.67: these cases are labeled as Cases C and D, respectively. An increase in the tax revenue from labor income is offset by a decrease in the tax rate on consumption, under revenue neutrality.

4 Cases B-1, C-1, and D-1 (progressive expenditure tax)

In Cases B, C, and D, a progressive expenditure tax covers the overall tax revenue:⁵ these cases are labeled as B-1, C-1, and D-1, respectively. The degree of tax progressivity on expenditure is determined as follows: the parameter value of α (i.e., a constant part) is set to zero value; the parameter value of β (i.e., a coefficient to a level of expenditure) is adjusted under tax revenue neutrality. Labor income and interest income are not taxed.

8.3.3 Specification of parameters

This chapter examines the implications of alternative tax policies for an aging Japanese economy, through comparing steady states. Hence, we choose parameter values realistic for the economy. As a result, the economic variables in the benchmark case A, such as

the ratio of capital to income (K/Y) or that of capital to labor (K/L), are close to the values that are suggested by the *Annual Report on National Accounts (Kokumin Keizai Keisan Nenpo) 2000*, Economic Planning Agency, Japan (2000) (see Table 8.4 for the parameter values used in the simulation).

Survival probabilities (p_s) are calculated from the *Population Projections for Japan 1996-2100*, a 1997 publication by the Institute of Population Problems of the Ministry of Health and Welfare. Our model makes no sex distinction, and so this study uses the male-female average values for 2000 and 2025. Based on the above data, the percentages of aged population (65 or above) to the total population (21 or above) in 2000 and 2025 are 22.04 and 33.86 percent, respectively. Common growth rates of successive cohorts (n) are chosen so that the percentages in the simulation equal the estimated values.

As for the public pension system, the replacement ratio of pension payments (θ) in Case A is adjusted so that the contribution rate (τ_p) equals the actual value of 17.35 percent in employees' pension plans (*Kosei Nenkin*) in 2000. See Appendix 8.C for the method of assigning the weight given to each household's labor endowments.

8.4 Simulation results

According to Ohtake and Saito (1998), younger generations face a higher consumption inequality from the start of their life cycle: this finding suggests that within-cohort inequality may be transmitted from older generations to younger ones through intergenerational transfers. We investigate the general equilibrium effects of the introduction of a progressive expenditure tax, taking account of a situation where within-cohort inequality increases.

The aged-state simulations in 2025 will be focused mainly on and discussed below, because we are interested in how tax reforms will affect the Japanese economy in the future. See Tables 8.2 and 8.3 for the simulation results in the current and aged steady

states. In this chapter, the influence on capital accumulation is regarded as an indicator of efficiency. The reason is that under the assumption of an inelastic labor supply, the level of the total output depends solely on the level of capital stock, as indicated by equation (8.9). The social welfare function represented by equation (8.8) is dependent on the aspects of both efficiency and equity.⁶

8.4.1 Findings and their interpretation

1 Same variance cases ($\sigma = 0.635$) : Cases B and B-1

Cases B (the aged-state benchmark case) and B-1 in 2025 have the same dispersion in the within-cohort distribution of earnings ability as in the current benchmark case A in 2000. In Case B, a consumption tax covers the extra tax burden accompanying a transition to an aging society. As a result, the tax rate on consumption increases to 6.761 percent. By the move from Case A to B, the capital-labor ratio (K/L) diminishes from 3.007 to 2.915 and the wage rate decreases from 1 to 0.9944. Thus, the level of social welfare deteriorates from -72.12 to -141.57. Capital accumulation is lower in aged-state cases than in current-state cases for two possible reasons: one is that in an aged society, there are many generations who dissave their assets based on their life-cycle motive; the other is that the payroll tax (i.e., contribution rate) rises sharply from 17.35 percent to 30.79 percent. Therefore, the tax policies that stimulate capital accumulation may be required in an aging society.

In Case B-1, a progressive expenditure tax covers the total tax revenue. This case is one extreme example of tax policy to overcome serious damage to social welfare. By switching from Case B to B-1, the capital-labor ratio (K/L) increases to 4.262, and the level of social welfare makes a substantial recovery to -98.77. Thus, Case B-1 may show the guidelines of structural tax reforms.

2 Large variance cases ($\sigma = 0.65$) : Cases C and C-1

The variance of the within-cohort income distribution increases in the 'Case-C'

simulations. In the transition from Cases-B to Cases-C, the standard deviation increases from 0.635 to 0.65. Under progressive taxation, this change generates an increase in tax revenue. Moving from Case B to C, the tax revenue from labor income rises from 7.456 to 7.596. Consequently, the revenue-neutral tax rate on consumption in Case C rises to 6.658 percent. The level of social welfare of -170.33 in Case C is lower than that of -141.57 in Case B.

A possible reason is that the capital-labor ratio (K/L) of 2.906 in Case C is lower than that of 2.915 in Case B. Therefore, aggregate consumption is lower in Case C than in Case B, which may explain a deterioration of social welfare in Case C. Another possible reason is as follows. We employ the social welfare function represented by equation (8.8). The function is maximized if all households have the same level of consumption. Within-cohort inequality of consumption is higher in Case C than in Case B, which may diminish the social welfare level in Case C.

In Case C-1 a progressive expenditure tax covers the overall tax revenue, which is similar to Case B-1. The capital-labor ratio (K/L) of 4.256 in Case C-1 is much higher than 2.906 in Case C. Thus, the level of social welfare of -118.30 in Case C-1 is better than -170.33 in Case C. These results, quantitatively, that even in a situation where within-cohort inequality will increase, introducing a progressive expenditure tax and setting an appropriate degree of tax progressivity may avoid a drastic deterioration of social welfare.

3 Larger variance cases ($\sigma = 0.67$) : Cases D and D-1

Cases D and D-1 correspond respectively to Cases C and C-1. The within-cohort inequality is higher in Cases-D than in Cases-C: the standard deviation in Cases-D expands to 0.67. By switching from Case C to D, the capital-labor ratio (K/L) reduces from 2.906 to 2.894 and the level of social welfare declines from -170.33 to -219.40 . In Case D-1, the ratio jumps up to 4.247 and the level rises to -151.17 . Therefore, the level of social welfare is lower in Cases-D than in Cases-C, respectively. The qualitative result is the same between Cases-D and Cases-C, but the quantitative result is greater

in Cases-D compared with Cases-C, respectively.

8.4.2 Distortions of progressive expenditure taxation on individual behavior

Finally, we investigate distortions of progressive expenditure taxation on individual consumption-savings behavior. Since households that maximize their lifetime utility are unwilling to accept high tax rates, they make the level of consumption (or expenditure) in each age gentler over an entire lifetime under progressive expenditure taxation. Figure 8.1 presents that the age-profile of consumption is gentler and lower under progressive expenditure taxation (Case B-1) than under the aged-state benchmark case B (see Chapter 4 for further details of this observation).

8.5 Conclusions

This chapter, in a quantitative way, has investigated the macroeconomic and welfare effects of introducing a progressive expenditure tax in a situation with the aging of the Japanese population. The chapter has simulated capital accumulation and social welfare by taking account of the general equilibrium effects of the intragenerational inequality to predict the future aged society.

Our simulation results show that in a situation where the within-cohort inequality increases, a shift to progressive expenditure taxation may improve the expected lifetime utility substantially by offsetting negative effects of an aging population. We recommend a shift from progressive labor income taxation to progressive expenditure taxation, because this new type of tax schedule has two merits.

One is that a shift to consumption-based taxation improves the welfare by increasing the steady state capital stock. In an aged society, there are many generations who dissave their assets based on the life-cycle motive, and the payroll tax (i.e., contribution rate) sharply rises because the current Japanese public pension program is operated in a manner that is almost similar to a pay-as-you-go style. Thus, tax policies enhancing capital accumulation are desirable in an aging Japan where the capital stock

would decline. This new type of tax system is superior to other tax systems, especially as regards capital accumulation.

The other is that the tax progressivity on expenditure efficiently reduces the within-cohort dispersion of lifetime earnings, thus improving the social welfare. Hence, we propose that income redistribution should be achieved by incorporating progressivity into an expenditure tax.

Therefore, the simulation results suggest, quantitatively, some advantages of progressive expenditure taxation. We recommend a progressive expenditure tax as one of the most desirable tax regimes in an aging Japan, in terms of efficiency and equity grounds.

Appendix 8.A

To consider the utility maximization problem over time for each household, namely the maximization of equation (8.3) subject to equation (8.4), let the Lagrange function be

$$L(x) = U(x) + \sum_{s=1}^{75} \lambda_s(x) [-A_{s+1}(x) + \{1 + r(1 - \tau_r)\} A_s(x) + \{1 - \tau_w(wxe_s) - \tau_p\} wxe_s + b_s(x) + a_s(x) - (1 + \tau_c\{C_s(x)\}) C_s(x)],$$

where $\lambda_s(x)$ represents the Lagrange multiplier for equation (8.4).

The first-order conditions for $s = 1, 2, \dots, 75$ can be expressed by

$$\frac{\partial L(x)}{\partial C_s(x)} = p_s(1 + \delta)^{-(s-1)} \{C_s(x)\}^{-\frac{1}{\gamma}} - \lambda_s(x) [1 + \tau_c\{C_s(x)\}] = 0, \quad (8.A)$$

$$\frac{\partial L(x)}{\partial A_{s+1}(x)} = -\lambda_s(x) + \lambda_{s+1}(x) \{1 + r(1 - \tau_r)\} = 0. \quad (8.B)$$

The combination of equations (8.A) and (8.B) yields the equation that determines the slope of the age-consumption profile over the life cycle:

$$C_{s+1}(x) = \left[\left(\frac{p_{s+1}}{p_s} \right) \left\{ \frac{1 + r(1 - \tau_r)}{1 + \delta} \right\} \left(\frac{1 + \tau_c\{C_s(x)\}}{1 + \tau_c\{C_{s+1}(x)\}} \right) \right]^\gamma C_s(x). \quad (8.7)$$

For a given $C_1(x)$, equation (8.7) solves the path for consumption. The transformation

of equation (8.7) leads to the following expression:

$$C_s(x) = \left[\left(\frac{p_s}{p_1} \right) \left\{ \frac{1 + \bar{\tau}_c \{C_1(x)\}}{1 + \bar{\tau}_c \{C_s(x)\}} \right\} \right]^{\gamma} \left\{ \frac{1 + r(1 - \tau_r)}{1 + \delta} \right\}^{r(s-1)} C_1(x). \quad (8.7)'$$

Integrating equation (8.4) and using the initial and terminal conditions,

$A_1(x) = A_{76}(x) = 0$, caused by no intended bequests, produce the following equation:

$$\begin{aligned} \sum_{s=1}^{75} \{1 + r(1 - \tau_r)\}^{-(s-1)} [1 + \tau_c \{C_s(x)\}] C_s(x) &= \sum_{s=1}^{RE} \{1 + r(1 - \tau_r)\}^{-(s-1)} [1 - \tau_w(wxe_s) - \tau_p] wx e_s \\ &+ \sum_{s=ST}^{75} \{1 + r(1 - \tau_r)\}^{-(s-1)} b_s(x) + \{1 + r(1 - \tau_r)\}^{-29} a_{30}(x). \end{aligned}$$

To derive $C_1(x)$, equation (8.7)' is substituted into this lifetime budget constraint. Thus, we can find an optimum solution for $C_1(x)$.

Appendix 8.B

Section 8.2 describes the basic structure of households in the simulation model. This appendix presents those of firms and the government, and market equilibrium conditions.

Firm behavior

The production function is assumed to be of the constant elasticity of substitution form:

$$Y_t = B \left[\varepsilon K_t^{\frac{1-\frac{1}{\rho}}{\rho}} + (1 - \varepsilon) L_t^{\frac{1-\frac{1}{\rho}}{\rho}} \right]^{\frac{1}{1-\frac{1}{\rho}}}, \quad (8.9)$$

where Y_t represents the total output, K_t the total capital, L_t the total labor supply measured by the efficiency units, B a scaling constant, ε a parameter measuring the intensity of use of capital in production, and ρ the elasticity of substitution between K_t and L_t . Using the property subject to a constant-returns-to-scale production function, we can obtain the following equation:

$$Y_t = rK_t + wL_t. \quad (8.10)$$

Government behavior

The budget constraint of the narrower government sector at time t is given by

$$G_t = T_t, \quad (8.11)$$

where G_t is government spending on goods and services in year t , and T_t is the overall tax revenue from labor income, interest income, and consumption. As for the pension system, a simple pay-as-you-go system is assumed. The budget constraint of the pension sector at time t is represented by

$$R_t = B_t, \quad (8.12)$$

where R_t is the total contribution to a public pension scheme, and B_t is the total public pension benefits to generations of age $ST + 20$ and above.

G_t , T_t , R_t , and B_t are defined respectively by

$$G_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} g, \quad (8.13)$$

$$T_t = TL_t + TC_t + \tau_r r AS_t, \quad (8.14)$$

$$R_t = \tau_p w L_t, \quad (8.15)$$

$$B_t = N_t \sum_{s=ST}^{75} p_s (1+n)^{-(s-1)} \int_0^\infty f(x) b_s(x) dx, \quad (8.16)$$

where g denotes the government expenditure per generation, TL_t and TC_t are respectively the tax revenue from labor income and consumption, and AS_t aggregate assets supplied by households.

Since labor income or expenditure (i.e., consumption) is progressively taxed, we get

$$TL_t = N_t \left[w \alpha \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s + \frac{1}{2} w^2 \beta \exp(\sigma^2) \sum_{s=1}^{RE} p_s (1+n)^{-(s-1)} e_s^2 \right], \quad (8.17)$$

$$TC_t = N_t \sum_{s=1}^{75} p_s (1+n)^{-(s-1)} \int_0^\infty f(x) \left[\alpha \{C_s(x)\} + \frac{1}{2} \beta \{C_s(x)\}^2 \right] dx. \quad (8.18)$$

See Appendix 7.B for further details of equations (8.17) and (8.18). AS_t is characterized by

$$AS_t = N_t [p_2(1+n)^{-1} \int_0^\infty f(x)A_2(x)dx + p_3(1+n)^{-2} \int_0^\infty f(x)A_3(x)dx + \dots + p_{75}(1+n)^{-74} \int_0^\infty f(x)A_{75}(x)dx]. \quad (8.19)$$

Market equilibrium

Finally, equilibrium conditions for the capital, labor, and goods markets are described.

1 Equilibrium condition for the capital market

$$AS_t = K_t. \quad (8.20)$$

2 Equilibrium condition for the labor market

$$L_t = N_t \sum_{s=1}^{RE} p_s(1+n)^{-(s-1)} e_s. \quad (8.21)$$

3 Equilibrium condition for the goods market

$$Y_t = AC_t + (K_{t+1} - K_t) + G_t. \quad (8.22)$$

where AC_t denotes aggregate consumption that is represented by

$$AC_t = N_t \left[p_1 \int_0^\infty f(x)C_1(x)dx + p_2(1+n)^{-1} \int_0^\infty f(x)C_2(x)dx + \dots + p_{75}(1+n)^{-74} \int_0^\infty f(x)C_{75}(x)dx \right]$$

An iterative program is performed to obtain the equilibrium values of the above equations (see Appendix 7.C for the computation process).

Appendix 8.C

Table 8.5 shows data that includes all ranges of individual income taxes, by adding two sources: data for income tax collected at the tax office; and data for self-assessed income tax. The data is based on the *Statistical Year Dissertation of National Taxes (Kokuzeicho Tokei-Nenposho) 1998*, National Tax Administration Agency, Japan (2000). We explain the methods of assigning each weight given to labor endowments, the degree of tax progressivity on labor income, and the variance of the lifetime earnings-ability distribution.

We first explain how the weight x given to labor endowments of each household (which is described in Section 8.2) is assigned. Table 8.5 presents the proportion of each

income class and each amount of income. The weight x is defined as the ratio of annual income of each income class to average annual income (which is approximately 4.87 million yen). The weight x theoretically has values between zero and ∞ . The simulation, however, assumes the value to be between zero and 4.8 (the range covers 99.7 percent of all households) for the following reason: as for the high-income class whose weight x is extremely large, tax rates are too high under the progressive tax scheme adopted in the model.

Second, the method of assigning the parameters that determine the degree of tax progressivity on labor income in the current benchmark case A is described. Under the ordinary least squares (OLS) method, the parameters, α and β , should have been estimated using the tax rate on *labor income* as a dependent (explained) variable and $\frac{1}{2}wx\bar{e}$ as an independent (explanatory) variable. (Here, \bar{e} denotes the average value of e_s , which takes account of both the common growth rate of successive cohorts (n) and the survival probabilities (p_s) in 2000.) However, adequate data for this estimation is not presently available in Japan.

Hence, the estimation of the parameters in Case A is undertaken as a second best means in the order that follows. First, the constant-part parameter of α is estimated by the OLS method, using the average tax rate on *income* as a dependent variable and $\frac{1}{2}wx\bar{e}$ as an independent variable. Here, w is assigned to unity, and x is an average value of each income class presented by Table 8.5. Thus, we obtain -0.001762 as an estimated value of α . Next, given this value, the proportional-part parameter of β is chosen so that the average tax rate on labor income in Case A is 5.93 percent, which is calculated from the above data.

Finally, the means of assigning the variance of earnings-ability distribution within a cohort is explained. The method of estimating standard deviation in the density function denoted by equation (8.1) is described. The OLS method is employed to estimate standard deviation, σ . It is estimated by minimizing the sum of squared

differences between the observed and predicted probabilities:

$$\sum_{i=1}^{11} [\bar{P}_i - P_i(\sigma)]^2,$$

where i ($= 1, 2, \dots, 11$) represents a bracket of each income class indicated by Table 8.5,

\bar{P}_i is the number of observations in the i -th interval when the total number of people is normalized to unity, and $P_i(\sigma)$ is the theoretical probability of people in the same interval. Supposing that σ is the parameter of the theoretical distribution specified, then $P_i(\sigma)$ is defined by

$$P_i(\sigma) = \int_{x_{i-1}}^{x_i} f(x; \sigma) dx,$$

where x_i shows the upper end of the bracket of income class i , and $f(x; \sigma)$ is the density function. Thus, we get 0.635 as an estimated value of σ . For reference, the estimated value in Atoda *et al.* (1988) is 0.659.

Table 8.1 *Parameter values that characterize the two steady states*

	Current steady state (Case A)	Aged steady state (Cases B, C, and D)
Survival probabilities (p_s)	2000	2025
Growth rate of successive cohorts (n)	0.01056	-0.00515
New entrants in period t (N_t)	1.5	0.9154
Labor supply (L_t)	143.92	124.57
Contribution rate (τ_p)	0.1735	0.3079

Table 8.2 *The 2000 current benchmark case A and the 2025 aged state cases, B, C, and D*

Case	A (Current state benchmark)	B (Aged state benchmark)	C	D
Standard deviation (σ)	*0.635	*0.635	*0.65	*0.67
Tax rate on labor income ($\tau_w(wxe_s)$)	* $\begin{cases} \alpha = -0.00176 \\ \beta = 0.02485 \end{cases}$	* $\begin{cases} \alpha = -0.00176 \\ \beta = 0.02485 \end{cases}$	* $\begin{cases} \alpha = -0.00176 \\ \beta = 0.02485 \end{cases}$	* $\begin{cases} \alpha = -0.00176 \\ \beta = 0.02485 \end{cases}$
Tax rate on expenditure ($\tau_c\{C_s(x)\}$)	* $\begin{cases} \alpha = 0.05 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.06761 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.06658 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0.06513 \\ \beta = 0 \end{cases}$
Tax rate on interest income (τ_r)	0.2000	0.2000	0.2000	0.2000
Capital-labor ratio (K/L)	3.007	2.915	2.906	2.894
Income-labor ratio (Y/L)	1.120	1.116	1.116	1.115
Capital-income ratio (K/Y)	2.685	2.611	2.604	2.594
Interest rate (r)	0.0399	0.0418	0.0420	0.0423
Wage rate (w)	1.0000	0.9944	0.9939	0.9931
Total capital (K_t)	432.75	363.09	361.98	360.45
Social welfare (SW)	-72.12	-141.57	-170.33	-219.40
Tax revenue from labor income (X_t)	8.398	7.456	7.596	7.793

Note: Asterisks (*) before the rate indicate that the variable is exogenous.

Table 8.3 *Empirical results caused by the introduction of a progressive expenditure tax in the 2025 aged steady state*

<i>Case</i>	B-1 (Progressive expenditure tax)	C-1 (Progressive expenditure tax)	D-1 (Progressive expenditure tax)
Standard deviation (σ)	*0.635	*0.65	*0.67
Tax rate on labor income ($\tau_w(wxe_s)$)	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0 \end{cases}$
Tax rate on expenditure ($\tau_c\{C_s(x)\}$)	* $\begin{cases} \alpha = 0 \\ \beta = 0.11554 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0.11490 \end{cases}$	* $\begin{cases} \alpha = 0 \\ \beta = 0.11416 \end{cases}$
Tax rate on interest income (τ_r)	0.0000	0.0000	0.0000
Capital-labor ratio (K/L)	4.262	4.256	4.247
Income-labor ratio (Y/L)	1.158	1.158	1.158
Capital-income ratio (K/Y)	3.679	3.674	3.668
Interest rate (r)	0.0236	0.0237	0.0237
Wage rate (w)	1.0578	1.0576	1.0573
Total capital (K_t)	530.87	530.15	529.10
Social welfare (SW)	-98.77	-118.30	-151.17

Note: Asterisks (*) before the rate indicate that the variable is exogenous.

Table 8.4 *Parameter values used in simulation analysis*

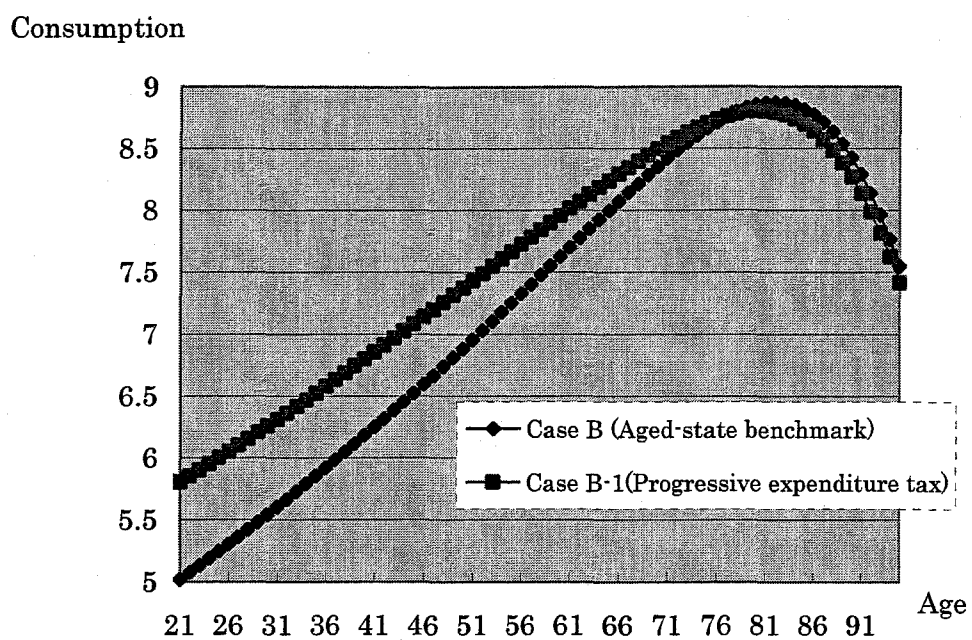
	Parameter values
Adjustment coefficient for discounting the future	$\delta = -0.022$
Intertemporal elasticity of substitution	$\gamma = 0.2$
Elasticity of substitution in production	$\rho = 0.6$
Weight parameter in production	$\varepsilon = 0.2$
Scale parameter in production	$B = 0.94991$
Government expenditure per generation	$g = 0.27989$
Retirement age	$RE = 40$
Starting age for receiving public pension benefit	$ST = 45$
Replacement ratio of public pension	$\theta = 0.55086$

Table 8.5 *Income distribution and taxes on households*

i	Income class (million yen)	Number of persons (,000)	Ratio (\bar{P}_i)	Amount of income (billion yen)	Average annual income (million yen)	x (Average)	x_i (Upper end)	Amount of taxes (billion yen)	Average tax rate on income (%)
1	~1	3,382	0.0655	2,554	0.76	0.15	0.205	20	0.78
2	1~2	5,540	0.1072	8,371	1.51	0.31	0.410	97	1.16
3	2~3	7,934	0.1536	20,056	2.53	0.52	0.615	429	2.14
4	3~4	9,073	0.1756	31,645	3.49	0.72	0.821	837	2.64
5	4~5	7,274	0.1408	32,603	4.48	0.92	1.026	905	2.78
6	5~6	5,293	0.1024	28,991	5.48	1.12	1.231	861	2.97
7	6~7	3,860	0.0747	24,921	6.46	1.32	1.436	870	3.49
8	7~8	2,716	0.0526	20,277	7.47	1.53	1.641	882	4.35
9	8~10	3,130	0.0606	27,760	8.87	1.82	2.052	1,667	6.01
10	10~15	2,440	0.0472	29,005	11.89	2.44	3.077	2,845	9.81
11	15~20	585	0.0113	9,964	17.03	3.49	4.103	1,539	15.45
12	20~	444	0.0086	15,705	35.37	7.26		3,977	25.32
	Total (average)	51,670	1	251,850	4.87	1		14,930	5.93

(Source: *Statistical Year Dissertation of National Taxes 1998*, National Tax Administration Agency, Japan (2000).)

Figure 8.1 *Comparison of age-consumption profiles between Cases B and B-1*



9 Summary and conclusion

This chapter summarizes and concludes this dissertation. It provides a summary of the whole dissertation, and individual summaries for the findings and conclusions in Chapters 2 through 8. It also suggests the reservations in our simulation analysis, and the challenging tasks for future research.

9.1 Summary of the whole dissertation

This dissertation has investigated the macroeconomic and welfare effects of structural tax and public pension reforms in Japan, a society with an aging population. A life-cycle general equilibrium simulation model developed by Auerbach and Kotlikoff (1983a) was employed to take account of the rapidly aging Japanese population. This dissertation has also compared various alternative tax regimes in terms of efficiency and equity to explore an optimum tax policy.

The simulation results in this dissertation suggest that capital stock will decline with an aging population. Two possible reasons are as follows: the first is that in an aging society, there are many generations who dissave their assets based on the life-cycle motive; the second is that the payroll tax (i.e., contribution rate) rises sharply. The results also show that progressive expenditure taxation stimulates much more capital accumulation than progressive labor income taxation. Therefore, it is ultimately desirable to shift from progressive labor income taxation to progressive expenditure taxation. The switchover from an income-based to a consumption-based tax system

should be executed gradually in an aging Japan. When progressive expenditure taxation is adopted as the nucleus tax regime, its combination with an inheritance tax is preferable in terms of efficiency and equity.

As for the structural reforms in the current Japanese system, the contributions to a public pension scheme in a pay-as-you-go system should be substituted by general taxes, especially, progressive expenditure taxation. Such possible integration of tax and social security systems is desirable in terms of efficiency and equity. We should promote the partial integration of tax and public pension systems as a transition process, substitute a consumption tax for the contributions, and implement a gradual shift towards perfect integration. Therefore, we recommend the introduction of progressive expenditure taxation with the complete integration of tax and public pension systems.

9.2 Individual summaries for Chapters 2 through 8

This section summarizes Chapters 2 through 8, and describes the challenging tasks for future research.

Chapter 2 investigated the relative efficiency of three alternative tax regimes, namely, a labor income tax, an interest income tax, and a consumption tax. Chapter 2 also demonstrated the effects of an interest income tax on household behavior and capital formation. The simulation results in Chapter 2 indicate that a consumption tax is the best method for enhancing capital accumulation; and that the negative effect of an interest income tax on capital formation is substantial. The simulation results also suggest, quantitatively, that the taxation on interest income distorts the intertemporal consumption choice, by raising the price of future consumption relative to current consumption. As a result, this promotes the substitution of future consumption with current consumption in households.

Chapter 3 examined the effects of progressive labor income taxation and progressive consumption taxation on capital accumulation and intragenerational income redistribution in Japan, where the population is undergoing an aging trend. The

simulation results show that under the progressive taxes do changes in the time path of taxation during an individual life-cycle stimulate capital formation. In contrast to progressive labor income taxation, the introduction of progressive consumption taxation increases the assets of the high-income class.

Chapter 4 investigated the quantitative effects of tax reform from progressive labor income taxation to progressive expenditure taxation, on capital accumulation and intragenerational income redistribution. The simulation results suggest that progressive expenditure taxation stimulates much more capital formation than progressive labor income taxation. Given that the age-profile of consumption has an upward slope, progressive expenditure taxation distorts individual behavior by raising the price of future consumption relative to current consumption. Nevertheless, the simulation results suggest that household behavior is less distorted under progressive expenditure taxation than under progressive labor income taxation.

Chapter 5 incorporated an inheritance tax into the simulation model, and explored an optimum "tax mix" policy in an aging Japan. The simulation results suggest that the Japanese tax system should rely more on an inheritance tax regime, because it will substantially stimulate capital formation and reduce the inequality of income distribution caused by bequests. The simulation results also show that when progressive expenditure taxation is adopted as the nucleus tax regime, its combination with an inheritance tax is preferable.

Chapter 6 explored guidelines for structural reforms of tax and social security systems in an aging Japan. The simulation model employed in Chapter 6 incorporates the basic pension into the public pension program. The simulation results show that the contributions to public pension scheme in a pay-as-you-go system should be substituted by general taxes, especially, progressive expenditure taxation. Such possible integration of tax and social security systems is desirable in terms of efficiency and equity. Therefore, we recommend the introduction of progressive expenditure taxation with the complete integration of tax and social security systems in an aging Japan.

Chapter 7 examined the general equilibrium effects of changes in the variance of income distribution on capital accumulation and social welfare in an aging Japan. The simulation results suggest that only under progressive taxation do changes in its variance affect aggregate economic variables; under proportional taxation, the changes have no influence on aggregate variables. The simulation results also show that social welfare substantially increases as the variance shrinks, and thus the recent tendency in Japan, where the progressive taxation system tends to become flat, may result in significant damage to social welfare.

Finally, Chapter 8 studied the macroeconomic and welfare effects of introducing progressive expenditure taxation in an aging Japan. The simulation in Chapter 8 takes account of the general equilibrium effects of intragenerational inequality, which increases with a transition to an aging society. The simulation results suggest that progressive expenditure taxation has advantages over progressive labor income taxation on grounds of efficiency and equity. The results indicate that a shift to progressive expenditure taxation might overcome the large welfare loss that would occur under the current Japanese tax system.

9.3 Reservations and suggestions for future research

The simulation results described in this dissertation are dependent on the given parameters. Hence, we must be careful about the effects of any parameter changes. In particular, a slight change in the parameter of intertemporal elasticity of substitution, γ , substantially affects capital formation (see Appendix 2.B for the sensitivity analysis). It should be noted that the simulation results depend on particular parameter values, and the life-cycle growth model employed.

This section presents the reservations of our simulation analyses, and the challenging tasks for future research. It is especially important to mention two aspects neglected in our life-cycle simulation model. The first is the disincentive effect of progressive taxation on labor supply, and the second is transitional effects due to policy

switching.

1 Progressivity and labor supply

The life-cycle simulation model adopted in this dissertation assumes an *inelastic* labor supply. Therefore, there is only a partial impact of progressive taxation and no excess burden. An *elastic* labor supply needs to be introduced to analyze the effects of progressive taxation in a comprehensive way. The simulation results suggest that the higher the tax progressivity, the greater is the capital accumulation. Due to the assumption of an *inelastic* labor supply, an increase in progressiveness can diminish the dispersion of after-tax income without reducing the labor supply. If labor supply is *elastic*, this disincentive effect of progressive taxation will be damaging to social welfare. However, this effect does not matter so much when comparing progressive labor income taxation and progressive expenditure taxation.

In order to explain this, we mention the simulation results obtained by Auerbach and Kotlikoff (1987) in which labor supply is assumed to be *elastic*, and compare our simulation results with those set out in that paper. The simulation in that study makes two observations. First, with the move from proportionality to progressivity, the capital stock declines less under a consumption tax than under a labor income tax, which continues to leave the intertemporal consumption decision undistorted. Second, with the transfer from proportionality to progressivity, the decrease in labor supply is lesser under a consumption tax than under a labor income tax. Hence, that study suggests that household behavior is less distorted under an expenditure (or consumption) tax than under a labor income tax, especially in the case of progressive taxation.

Therefore, in our simulation, progressive labor income taxation has a significant advantage over progressive expenditure taxation, because our model assumes a completely *inelastic* labor supply. Nevertheless, our simulation results indicate that progressive expenditure taxation is superior to progressive labor income taxation in terms of efficiency and equity. This fact should be stressed when we recommend progressive expenditure taxation as one of the most desirable tax regimes.

2 Limitations of steady state analyses

Although we employed a life-cycle general equilibrium simulation model with overlapping generations, our simulations in this dissertation are limited only to the steady states. The model takes account of the effects of demographics, by comparing the two steady states, namely, current and aged. Thus, our study lacks the consideration of a transitional path. Tax and social security reforms have different effects on different generations. Specifically, current and future generations experience different impacts of these reforms. A transitional process from the current progressive labor income taxation to the progressive expenditure taxation will generate intergenerational inequality. For example, the aged population group might bear an unfair tax burden, because they might have paid a large amount of income tax during their working period and have to pay a large amount of expenditure tax during their retirement period.

Therefore, it is necessary to take account of not only steady states but also a transitional process in an aging society. The life-cycle simulation model is appropriate as a basic theoretical framework to examine the problems caused by demographic changes. In order to further display the advantages of the model, a transitional process should be investigated as the next step.

3 Human capital investment

Human capital has played a significant dual role in economic literature – as a fundamental source of aggregate growth, and as a factor to explain the observed profile of earnings, work time, and training over the life cycle. By extending the Auerbach-Kotlikoff simulation model, Arrau (1992) integrates the role of human capital as an engine of growth and as a determinant of life-cycle profiles of earnings and labor supply. Thus, human capital investment needs to be incorporated into our life-cycle general equilibrium simulation model.

4 Strategic bequest motives

The model in this dissertation deals only with the unintended bequests consistent with uncertainty regarding the length of individual life. Horioka *et al.* (2000) suggest that

unintended bequests and strategic bequest motives make up the majority of bequests in Japan (see Chapter 1 for further details). Therefore, strategic bequest motives, which are one of the intended bequest motives, should be also included into the model.

5 Public insurance on the care for the elderly

We have found that a life-cycle general equilibrium simulation model is useful to explore desirable tax and social security systems. Hence, we will continue to improve the model to provide a reasonably good description of the actual Japanese economy. There are only a few studies on the care for the elderly in the public insurance system, because this new system has just come into effect from April 2000. Since the system will hold an increasingly significant position in the social security system in an aging Japan, we will try to analyze the care for the elderly in the public insurance system.¹

Notes

Chapter 1

- 1 Bernheim *et al.* (1985) address strategic bequests motives.
- 2 To handle intragenerational income redistribution, Auerbach and Kotlikoff (1983a) consider a model in which each cohort has three representative individuals, corresponding to three income classes: poor, median, and wealthy. Fullerton and Rogers (1993) or Altig *et al.* (2001) deal with differences of lifetime earnings ability, by incorporating twelve lifetime-income groups into a life-cycle model. Miyazato and Kaneko (2001) also address the problem of intragenerational inequality and undertook an analysis on the public pension reform.

Chapter 2

- 1 In a model without uncertainty regarding the length of life, the age-profile of consumption is linear and has an upward slope. With the introduction of life-length uncertainty, as considered in our model, the profile is no longer linear (see Figures 2.1-2.4 for age-profiles of consumption). The level of consumption at the final stage of old ages is low, because the weight on consumption diminishes. Since such consumption-savings behavior is realistic, economic values such as aggregate consumption or the capital stock can be also realistic in our simulation.
- 2 Kato (1998) explicitly separates a labor income tax and an interest income tax.
- 3 An elastic labor supply can be assumed by incorporating leisure into the utility function in addition to consumption, such as in Auerbach and Kotlikoff (1987) or in

Altig *et al.* (2001). Several recent investigations, however, show that labor supply is fairly inelastic for the after-tax wage rate *in Japan*. For instance, Asano and Fukushima (1994) report that the estimated value of compensated elasticity of labor supply is 0.27. It should be noted that their study estimates only the size of the substitution effect. If the income effect were also estimated, a still smaller elasticity of labor supply for the after-tax wage rate would be obtained *in Japan*.

- 4 The subjective discount rate at age $s + 20$ can be calculated by considering each survival probability, p_s , in addition to a constant adjustment coefficient, δ . It is verified that the subjective discount rates have positive values.
- 5 We assume that there exists a borrowing market and thus that A_s has a negative value. When households are borrowing (i.e., when A_s is negative), it is assumed that the government helps them financially with the rate τ_r . On the other hand, Iwamoto (1990) or Kato (1998) imposes a liquidity constraint ($A_s(x) \geq 0$) so that households do not have negative assets.
- 6 As for the estimation of the age-profile of earnings ability, e_s , we employ the parameter values in Homma (1987a):

$$Q = a_0 + a_1N + a_2N^2 + a_3K + a_4K^2,$$

where Q denotes average monthly cash earnings, N age, and K the length of one's service for men workers. Table 2.1 presents their results of estimation using data from the *Basic Survey on Wage Structure 1984* by the Ministry of Labor.

- 7 Auerbach *et al.* (1989) or Iwamoto *et al.* (1993) introduce intended bequests into their model. In those studies, bequests arise from the "joy of giving."
- 8 There are two methods to deal with uncertainty regarding the length of life. One method is to consider unintended bequests and to transfer them between different generations, which is adopted in this dissertation. The other method is to take account of annuity markets as considered in Iwamoto *et al.* (1993). In that study, there is a private pension market consistent with life-length uncertainty.
- 9 Our setting of a bequest motive is the same as that considered in e.g., Iwamoto (1990). Atoda and Kato (1993) investigate the influences of the timing when this

bequest is inherited.

- 10 The rate of n in our model is a gross size rate. It signifies the simple ratio of the size between a cohort and the successive cohort, without taking account of survival probabilities, p_s .
- 11 The utility function represented by equation (2.2) has negative values, and smaller absolute values indicate higher levels of utility. As consumption and utility level increase, a numerical value of utility approaches the upper limit, zero, and the corresponding size of a numerical increase becomes smaller.
- 12 Chapter 6 incorporates the basic pension (i.e., the flat part) into the public pension program. In Chapter 6, the general tax revenue covers one-third of the basic pension, along the lines of the current Japanese tax and public pension systems.
- 13 In an aging society Japan faces a decline in the proportion of the working population, with a subsequent decrease in aggregate output; hence the rising ratio of the total government expenditure to aggregate output increases a substantial tax burden in an aged steady state.
- 14 The average tax rate on income (i.e., the ratio of the tax revenue from individual income to GDP) was 8.4 percent in Japan in 1990. Considering the fact that this figure includes the tax revenue from interest income, the tax rate on labor income is set to 7 percent in this chapter. As reference, in Kato (1998), the tax rate on labor income is set to 6.5 percent.
- 15 We implemented additional simulation cases without a public pension system. As a result, the capital stock increases substantially. When there is no pension system, all expenses in the old period must be covered only by private assets. Therefore, households accumulate more assets during their working period, resulting in a higher level of capital formation.
- 16 The simulation with a 65-percent replacement ratio generates a 19.1-percent contribution rate in the current state, which is higher than the 1995 rate of 16.5 percent in employees' pension plans (*Kosei Nenkin*). However, if we consider that this rate was raised to 17.35 percent in October 1996, the contribution rate of 19.1

percent should be acceptable. If we choose a replacement ratio of more than 65 percent, the contribution rate produced in the simulation would be too high.

17 This remark also holds true for the simulation analysis in Chapters 3 to 8.

18 Since this chapter assumes the existence of a single representative household in every cohort, we cannot deal with the problem of intragenerational income redistribution. This is a significant topic, because a consumption tax is likely to be regressive. This problem will be solved in Chapters 3 through 8, by incorporating a diverse range of individuals with unequal incomes in each cohort.

Chapter 3

- 1 Chapters 3 through 6 incorporate plural representative individuals with unequal lifetime earnings ability. Furthermore, Chapters 7 and 8 incorporate numerous representative households with continuous income distribution in each cohort.
- 2 In case of an overlapping generations model with 80-period life cycles where households can live to a maximum of 100, as considered in Chapter 2, households' assets have negative values after 90. The reason is that households obtain the fixed amount of pension benefits until they die. At the final stage of old age, survival probabilities decrease drastically, and thus the households that maximize their expected utility choose a low level of consumption. It is possible to rule out unrealistic behavior of negative assets after 90, by assuming a 75-period life-cycle model as considered in Chapters 3 to 8. See Figure 3.1 or 3.2 for the age-profiles of assets.

- 3 To estimate the age-profile of earnings ability, e_s , the following equation is used:

$$Q = a_0 + a_1N + a_2N^2,$$

where Q denotes average monthly cash earnings and N age. Using data from the *Basic Survey on Wage Structure 1995* by the Ministry of Labor, parameters are estimated as shown in Table 3.5. In Japan, bonuses account for a large part of earnings. Therefore, monthly cash earnings used here also contain bonuses.

- 4 The tax rate on interest income is set to Japan's actual constant rate of 20 percent.

Hence, a progressive tax schedule is not applied to interest income in our simulation.

- 5 When progressive taxation is introduced, the tax burden for the low-income class diminishes, while it increases for the high-income class. Because of the particular form of utility function employed in our model, a numerical increase in utility for the low-income class is large, while a numerical decrease for the high-income class is small. Since our social welfare function is derived from a simple summation of the utilities of different income classes, our study lays a substantial emphasis on the welfare of the low-income class.
- 6 The tax revenues from labor income, interest income, and consumption are respectively the same across the current-state cases, A, A-1, and A-2. This remark also holds true for the aged-state cases, B, B-1, and B-2. This is because different tax compositions across simulation cases would have some effects on the economy, even under the constant total tax revenue.
- 7 Of course, other financial methods such as a labor income tax or an interest income tax, can cover the tax burden that increases with an aging population. Different financing methods generate different impacts on the economy (see Chapter 2 for further details).
- 8 The whole average tax rate on labor income is set to 6.5 percent, which is the same value as in Kato (1998).
- 9 This remark also holds true for analysis in Chapters 4 through 8.
- 10 This remark also holds true for analysis in Chapters 4, 6, 7, and 8.
- 11 This remark also holds true for analysis in Chapters 4 through 8.

Chapter 4

- 1 To estimate the age-profile of earnings ability, e_s , the following equation is employed:

$$Q = a_0 + a_1A + a_2A^2 + a_3L + a_4L^2,$$

where Q denotes average monthly cash earnings, A age, and L the length of one's service for men workers. Table 4.1 presents the estimated parameter values using data from the *Basic Survey on Wage Structure 1998* by the Ministry of Labor. Monthly cash earnings used here contain bonuses, because in Japan, bonuses account for a large part of earnings.

- 2 See Seidman (1997) for the details of a progressive consumption (expenditure) tax.
- 3 Kaldor (1955) claims that the implicit taxation of individuals with vast inherited wealth via an expenditure tax is a final goal.

Chapter 5

- 1 Kato (1998) or Miyazato and Kaneko (2001) introduce an inheritance tax into a life-cycle general equilibrium model. Since those studies focus on the analysis of public pension policies, their purpose is different from ours.
- 2 To estimate the age-profile of earnings ability, e_s , the following equation is employed:

$$Q = a_0 + a_1A + a_2A^2 + a_3L + a_4L^2,$$

where Q denotes average monthly cash earnings, A age, and L the length of one's service for men workers. Table 5.1 presents the parameter values estimated using data from the *Basic Survey on Wage Structure 1999* by the Ministry of Labor. Monthly cash earnings used here contain bonuses, because bonuses account for a large part of earnings in Japan.

- 3 For the simplicity of discussion, this chapter assumes a proportional tax rate on inheritance, although it is actually progressive. The rate is set to 10 percent, which is estimated using data by the *Statistical Year Dissertation of National Taxes (Kokuzeicho Tokei-Nenposho) 1998*, National Tax Administration Agency, Japan (2000).
- 4 In terms of the "postponement effect," Seidman (1983) explains the effect of an inheritance tax. That study suggests that what matters for the capital-labor ratio (K/L) is the age when a tax is paid: the later you pay, the higher the ratio.

- 5 See e.g., Ihori (1996) for the details of intergenerational transfers.

Chapter 6

- 1 In Japan, it has been discussed that the ratio of one-third will be raised to a half in the near future. Uemura (2001) considers this matter in the framework including a transitional process.

Chapter 7

- 1 To estimate the age-profile of earnings ability, e_s , the following equation is used:

$$Q = a_0 + a_1N + a_2N^2,$$

- where Q denotes average monthly cash earnings and N age. Using data from the *Basic Survey on Wage Structure 1994* by the Ministry of Labor, the above parameters are estimated as indicated in Table 7.1. In Japan, bonuses account for a large part of earnings. Therefore, monthly cash earnings used here also contain bonuses.
- 2 This assumption is made for simplicity of argument. Of course, in reality, parents and children do not always have the same lifetime earnings ability.
- 3 The income class whose weight x given to labor endowments is close to zero cannot survive in reality. Thus, it may be more realistic to employ the social welfare function that excludes this income class.
- 4 See Chapter 8 for an analysis in an aged steady state.
- 5 This remark also holds true for analysis in Chapter 8. See Appendix 3.C for the sensitivity analysis on exogenous changes in labor supply.
- 6 This remark also holds true for analysis in Chapter 8.

Chapter 8

- 1 Ohtake and Saito (1998) suggest that half of the rapid increase in the economy-wide consumption inequality during the 1980s was caused by population aging, while one-third was due to the increasing cohort effect. It should be noted that our

analysis does not focus on the former but the latter.

- 2 See Note 2 to Chapter 5 for the estimation of the age-profile of earnings ability, e_s .
- 3 In order to ascertain the clear effects of tax reforms, tax revenue neutrality is assumed in all the simulation cases. The total tax revenue (T_t) is kept identical in all cases in the method that follows. New entrants in period t (N_t) are chosen so that the overall number of households is the same between the current and aged steady states. Therefore, the size of population is the same across all cases. Since the government expenditure per household is exogenously given and constant across all cases, the total tax revenue (T_t) is also constant.
- 4 In the simulation, we arbitrarily assign the parameter values on the increased within-cohort inequality. If the estimated values on an empirical basis are available, the realistic values should be, of course, employed.
- 5 Interest income is not taxed in the simulation. This is because we explore an optimum tax regime that provides for the promotion of capital accumulation. Since the tax exemption of interest income encourages savings, capital formation will be stimulated through not only the introduction of progressive expenditure taxation but also the exemption itself.
- 6 The weights attached to efficiency and equity are given in the model. To rigorously see the degree of equity, it is necessary to employ some measures of inequality such as Gini coefficient.

Chapter 9

- 1 Ueda (2000) undertook an economic analysis of the care for the elderly, using a life-cycle general equilibrium simulation model.

References

- Altig, D., Auerbach, A. J., Kotlikoff, L. J., Smetters, K. A., and Walliser, J. (2001) "Simulating fundamental tax reform in the United States," *American Economic Review* 91(3): 574-95.
- Arrau, P. (1992) "Endogenous growth in a life-cycle model: the role of population growth and taxation," *Journal of Policy Modeling* 14(2): 167-86.
- Asano, S. and Fukushima, T. (1994) "Some empirical evidence on demand system and optimal commodity taxation," *Discussion Papers in Economics and Business*, 94-01, Faculty of Economics, Osaka University.
- Atkinson, A. and Stiglitz, J. E. (1976) "The design of tax structure: direct versus indirect taxation," *Journal of Public Economics* 6: 55-75.
- Atoda, N. and Kato, R. (1993) "Savings and taxation system in the transition to aging Japan," *Tezukayama University Discussion Paper*, J-034, Tezukayama University (in Japanese).
- Atoda, N., Suruga, T., and Tachibanaki, T. (1988) "Statistical inference of functional forms for income distribution," *The Economic Studies Quarterly* 39(1): 14-40.
- Auerbach, A. J. and Kotlikoff, L. J. (1983a) "National savings, economic welfare, and the structure of taxation," in M. Feldstein (eds), *Behavioral Simulation Methods in Tax Policy Analysis*, Chicago: University of Chicago Press, 459-98.
- Auerbach, A. J. and Kotlikoff, L. J. (1983b) "An examination of empirical tests of social security and savings," in E. Helpman *et al.* (eds), *Social Policy Evaluation: An Economic Perspective*, New York: Academic Press, 161-79.

- Auerbach, A. J. and Kotlikoff, L. J. (1987) *Dynamic Fiscal Policy*, Cambridge: Cambridge University Press.
- Auerbach, A. J., Kotlikoff, L. J., Hagemann, R. P., and Nicoletti, G. (1989) "The economic dynamics of an aging population: the case of four OECD countries," *NBER Working Paper*, 2797.
- Bernheim, B. D., Shleifer, A., and Summers, L. H. (1985), "The strategic bequest motive," *Journal of Political Economy* 93(6): 1045-76.
- Creedy, J. (1992) *Income, Inequality and the Life Cycle*, Aldershot: Edward Elgar.
- Fullerton, D. and Rogers, D. L. (1993) *Who Bears the Lifetime Tax Burden?*, Washington, DC: The Brookings Institution.
- Hatta, T. (1996) "The logic and the problem of a tax structure," in K. Kinoshita and H. Kaneko (eds), *The Logic of a Taxation System in the 21st Century*, Zeimu Keiri Kyokai (Tokyo), 1: 25-58 (in Japanese).
- Hausman, J. (1979) "Individual discount rates and utilization of energy using durables," *Bell Journal*, Spring.
- Homma, M., Atoda, N., Iwamoto, Y., and Ohtake, F. (1987a) "Pension: aging society and pension plan," in K. Hamada, A. Horiuchi, and M. Kuroda (eds), *Macroeconomic Analysis of the Japanese Economy*, Tokyo University Shuppankai, 149-75 (in Japanese).
- Homma, M., Atoda, N., Iwamoto, Y., and Ohtake, F. (1987b) "Life-cycle growth model and sensitivity analysis," *Osaka Economic Papers*, Osaka University, 36(3/4): 99-108 (in Japanese).
- Horioka, C. Y., Nishikawa, M., Iwamoto, S., and Kouno, T. (2000) "The importance and properties of bequest motives, and their effects on the behavior of parents and children," presented at *the Annual Meeting of the Japanese Economic Association*, Osaka Prefecture University (in Japanese).
- Ihori, T. (1994) "Savings, investment, and taxation", in Y. Noguchi (eds), *A New Plan of Tax Reform*, Nippon Keizai Shinbun-sha, 51-86 (in Japanese).
- Ihori, T. (1996) *Public Finance in an Overlapping Generations Economy*, London:

Macmillan.

- Iwamoto, Y. (1990) "Pension plan and bequest behavior," *Quarterly Journal of Social Security Research*, 25(4): 388-411 (in Japanese).
- Iwamoto, Y., Kato, R., and Hidaka, M. (1993) "Public pensions and an aging population," *Review of Social Policy*, 2: 1-10.
- Kaldor, N. (1955) *An Expenditure Tax*, London: George Allen and Unwin.
- Kato, R. (1998) "Transition to an aging Japan: public pension, savings, and capital taxation," *Journal of the Japanese and International Economies* 12: 204-31.
- Kotlikoff, L. J. and Summers, L. H. (1981) "The role of intergenerational transfers in aggregate capital accumulation," *Journal of Political Economy* 89(4): 706-32.
- Lawrence, E. (1986) "The savings behavior of rich and poor: a study of time preference and liquidity constraints," Ph.D dissertation, Yale University.
- Miyajima, H. (1986) *Development of Tax Theory and the Japanese Tax System*, Nihon-hyouron-sha (in Japanese).
- Miyazato, N. and Kaneko, Y. (2001) "A dynamic macroeconomic analysis on public pension reform for achieving intergenerational and intragenerational equality," *Review of Social Policy* 37(2): 174-82 (in Japanese).
- Ohtake, F. and Saito, M. (1998) "Population aging and consumption inequality in Japan," *Review of Income and Wealth* 44(3): 361-81.
- Okamoto, A. (1996) "On the distortion effect associated with interest income taxation in aging Japan: simulation analysis by applying the life-cycle general equilibrium model," *Kyoto University Economic Review* 157(4): 16-29/158(2): 58-74 (in Japanese).
- Okamoto, A. (2000a) "Heterogeneous labor endowments and tax reforms in aging Japan: progressive taxes and intragenerational redistribution," *Okayama Economic Review* 32(1): 1-48 (in Japanese).
- Okamoto, A. (2000b) "Income distribution and tax reforms in aging Japan," *Okayama Economic Review* 32(2): 59-98 (in Japanese).
- Okamoto, A. (2002a) "Simulating tax-mix policies with inheritance taxes in aging

- Japan," *Discussion Paper*, I-45, Department of Economics, Okayama University.
- Okamoto, A. (2002b) "Within-cohort inequality and tax reforms in aging Japan," presented at the *International Forum on Tax Reforms in Japan* organized by Economic and Social Research Institute (ESRI), Cabinet Office (Government of Japan), September.
- Okamoto, A. "Simulating progressive expenditure taxation in aging Japan," forthcoming in *Journal of Policy Models*.
- Okamoto, A. and Tachibanaki, T. (2002) "Integration of tax and social security systems: on the financing methods of a public pension scheme in a pay-as-you-go system," in T. Ihori and T. Tachibanaki (eds), *Social Security Reform in Advanced Countries: Evaluating pension finance*, London and New York: Routledge, 132-60.
- Seidman, L. (1983) "Taxes in a life cycle growth model with bequests and inheritances," *American Economic Review* 73: 437-41.
- Seidman, L. (1997) *The USA Tax: a Progressive Consumption Tax*, Cambridge, MA: MIT Press.
- Summers, L. (1981) "Taxation and capital accumulation in a life cycle growth model," *American Economic Review* 71(4): 547-60.
- Ueda, A. (2000) *Economic Analysis of Care for the Elderly: Life-Cycle Theory and Housing Wealth*, Ph.D dissertation, International Christian University.
- Uemura, T. (2001) *Economic Analysis of the Financial Burden: Evaluation of Tax Reform and Pension Policy*, Kwansei Gakuin University Press.

Data

- Economic Planning Agency (1996-2002) *Annual Report on National Accounts (Kokumin Keizai Keisan Nenpo) 1996-2002*, Printing Bureau of Ministry of Finance, Japan.
- Economic Planning Agency (1996-2002) *Economic White Paper (Keizai Hakusho) 1996-2001*, Printing Bureau of Ministry of Finance, Japan.
- National Tax Administration Agency (1995-2002) *Statistical Year Book of National Taxes (Kokuzeicho Tokei-Nenposho) 1993-2000*, Japan.

- The Institute of Population Problems of the Ministry of Health and Welfare (1992)
Population Projections for Japan: 1991-2090 (estimation in September 1992), Japan.
- The Institute of Population Problems of the Ministry of Health and Welfare (1997)
Population Projections for Japan: 1996-2100 (estimation in September 1997), Japan.
- The Institute of Population Problems of the Ministry of Health and Welfare (2002)
Population Projections for Japan: 2001-2100 (estimation in September 2002), Japan.
- The Japan Cooperative Association (1996) *The Household Expenditure Survey 1995*,
Japan.
- The Ministry of Finance (2001)
<http://www.mof.go.jp/jouhou/syuzei/siryou/kozin/kozi09.htm>.
- The Ministry of Health and Welfare (1996-2002) *White Paper on Welfare 1996-2002*,
Japan.
- The Ministry of Labor (1995-2002) *Basic Survey on Wage Structure (Chingin Sensasu)*
1994-2001, Japan.